December 15, 1961

electronics

A McGraw-Hill Publication 75 Cents

(Photo at right)

BAKING A KLYSTRON

14-ft oven outgasses tube, activates cathode. *See p 86*

CORRELATING NAVIGATOR

uses microwave echoes at several antennas. *See p 55*

ELECTRONIC IGNITION

with thyratron, cold-cathode tube and transistor, p 62

NEW IDEAS IN TUBES

special cathodes, strap frame grids, shaped beams, p 60

UNIVERSITY MICROFILMS IN
EDITORIAL DEPT
313 N FIRST ST
ANN ARBOR MICH

a pleasure to measure with these...

5512A, 300 KC

5532A, 1.2 MC

4 NEW

SOLID STATE C

Measure frequency, period, ratio, quickly, accurately. Compact, easy-to-use instruments provide continuous display, no "blinking"! Solid-state dependability! 0.1 volt

All the advantages of solid-state design are now yours in these new solid state counters—offered at prices comparable to those of today's vacuum tube counters. And you get the *plus* advantages of greater readability, faster measurements, easier routine maintenance, rack-and-stack convenience of the new universal module instrument cabinets.

Offered in four models, these new counters have maximum counting rates of 300 KC or 1.2 MC, with a choice of Nixie or columnar readouts. The high-intensity neon readouts are stacked in compact columns for faster, easier reading. On the in-line readouts, -pioneered standard incorporation of the new long-life, wide-viewing Nixies gives you many extra hours of lamp life and heretofore unknown readability even at extreme angles. Polarized screen provides maximum readout brilliance with freedom from reflections.

A unique display storage feature of these new counters produces a continuous visual readout of the most recent measurement, even while the instrument is making a new measurement. Only if the new count differs from the previous count will the display change, in which case it will shift directly to the new reading. The fatigue and error possibility of a "blinking" display is eliminated. The storage feature may be disabled with a rear panel switch.

The counter's "inactive time" (when not making a new measurement) is independent of gate time and adjustable from 0.2 to 5.0 seconds, thus permitting a higher sampling rate.

Counter	Max. Counting Rate	Registration	Period and Multiple Period		Avera
			Range	Accuracy	Rea
5212A	300 KC	5 digits columnar	2 cps to 300 KC	± one count ± time base accuracy ± trigger error/periods averaged	Mil seco micr onds positi deci
5512A	300 KC	5 digits Nixie			
5232A	1.2 MC	6 digits columnar	2 cps to 1.2 MC	± 1 μs ± time base accuracy ± trigger error/ periods averaged	
5532A	1.2 MC	6 digits Nixie			

High sensitivity permits low level measurement without accessories, and multiple period average measurement (to 100,000 periods) gives higher ac-

Note clean, compact, easy-to-service physical arrangement of new solid-state counters.

5212A, 300 KC

5232A, 1.2 MC

COUNTERS!

sensitivity! Higher sampling rate! Unique low frequency accuracy! Operation —20° to +65° C! Prices comparable to vacuum tube counters!

od	Average Measurement		Frequency Measurement				Ratio Measurement			Price
	Reads in	Periods Averaged	Range	Accuracy	Reads In	Gate Time	Reads	Range	Accuracy	
ds	Milli-seconds or microsec-onds with positioned decimal	1, 10, 10^2, 10^3, 10^4, 10^5	2 cps to 300 KC	± 1 count ± time base accuracy	KC with positioned decimal	10, 1, 0.1, 0.01 sec.	(f_1/f_2) x period multiplier	f_1:100 cps to 300 KC (1 v rms into 1,000 ohms) f_2: same as period	± 1 count of f_1 ± trigger error of f_2	$ 975.00
										1,175.00
			2 cps to 1.2 MC					f_1: 100 cps to 1.2 MC (1 v rms into 500 ohms) f_2: same as period		1,300.00
										1,550.00

curacy in lower frequency ranges, even for noisy signals. Self-check is provided for both frequency and period measurement modes.

Only 3½" high, these counters are housed in the new hp modular cabinets ideal for both bench use and easy rack mounting. Routine maintenance is simple with snap-out decade/readout units and circuit cards. Readout drive directly from photoconductors eliminates a complete stage of complex circuitry, to effect genuine cost and reliability advantages. Compact design and construction and servicing ease are illustrated at the left.

Solid state design and construction gives you the advantages of low heat dissipation with minor heating effect on adjacent equipment, fast warm-up, low power consumption and new standards of reliability.

The new counters include a four-line BCD code output. This output, with assigned weights of 1-2-2-4 ("1" state positive with respect to "0" state), is available for systems use or to operate devices such as the hp 562A Digital Recorder. Controls include Input Attenuation, Display, Reset and Function.

Call or write your hp representative or call us today for information and a demonstration!

Data subject to change without notice. Prices f.o.b. factory.

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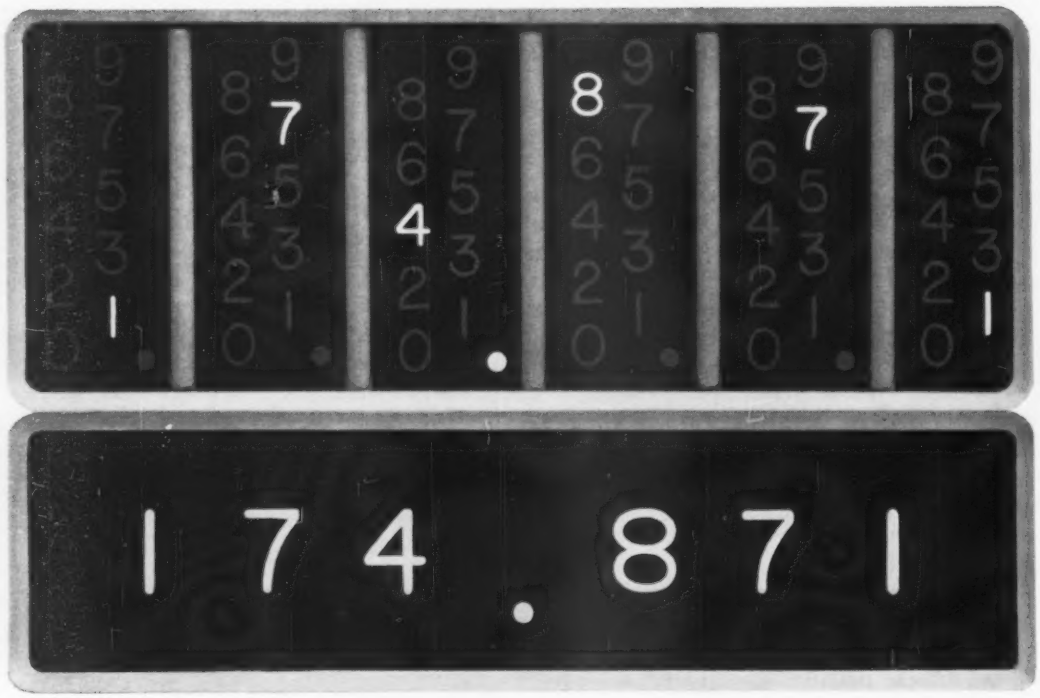
Higher sampling rate
Multi-period average
Wide temperature range
Low-frequency accuracy
Versatile new modular design
Measurement flexibility, moderate cost

IN 4 NEW hp SOLID STATE COUNTERS!



Turn the page to learn about new measuring convenience, dependability from hp.

December 15, 1961

electronics

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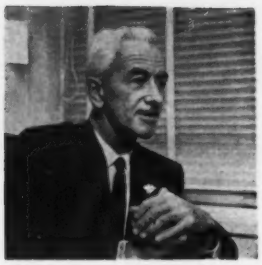

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High-power Klystron is lowered into 14-foot high-vacuum bakeout oven at Sperry Electron Tube division. Oven minimizes damage to tube if a leak develops at one of tube's seals. See p 86 COVER

NEW PULSE TRACKERS Readied for Space Ranges. Latest generation of missile range radars is capable of non-ambiguous range measurements of targets as far as 32,000 n. mi 26

Silver Price Jumps Nine Cents. Treasury stops selling metal, important in electronics, at deflated price 28

Thin Film Devices Are Still in Research Stage. Progress report on exploitation of tunneling in supercooled thin-films 30

AIR AND SPACE NAVIGATION Uses Correlation Technique. System reported is more accurate than comparable doppler types. R. J. Miller 55

Latest Developments in Electron Devices. Advances reported at the Radio Fall Meeting. L. Solomon 60

PRACTICAL ELECTRONIC IGNITION With Gas Tubes and Transistor. Thyratron switches high ignition currents around breaker points. H. P. Quinn 62

MEDICAL ELECTRONICS PART VI: Research Instruments. Laboratory equipments implement measurement and visualization of microscopic particles. W. E. Bushor 65

Hybrid Telemeter Detects Avalanches. Tripped wire controls tone-modulated signal. G. Neal and S. A. Stone 72

DEGENERATE PARAMETRIC AMPLIFIER Uses Butterfly Resonators. Suggests possibility of single-control continuous tuning. R. J. Mayer 74

Crosstalk	4	Components and Materials	80
Comment	6	Production Techniques	86
Electronics Newsletter	11	New on the Market	90
Washington Outlook	14	Literature of the Week	104
Meetings Ahead	32	People and Plants	106
Research and Development	76	Index to Advertisers	113

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AMPHENOL-BORG ELECTRONICS CORPORATION

electronics
December 15, 1961 Volume 34 No. 50

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CROSSTALK

Shelters Come Second

FIRST REQUIREMENT for effective civil defense is warning that an attack is imminent. With any kind of luck the military will know, but it is by no means certain that the warning can be relayed to the bulk of our population fast enough and clearly enough to be effective.

Sirens are fine and relatively foolproof but not everybody hears them. And there have been so many routine tests, as well as drills in which the public is not invited to participate, that they would be initially ignored and heeded only after the first missiles hit. In a saturation attack this might be too late.

Electric alarms installed in homes and elsewhere, triggered over the power lines, are currently under consideration. Such supplementary devices, useful as they would be in spreading warning to people beyond the reach of sirens, have a similar weakness. They would warn the public, but not tell the public why it was being warned and what to do about it. Stating this another way, they would not be able to talk.

We should certainly have a supplementary alarm system, but that system should be operated by radio.

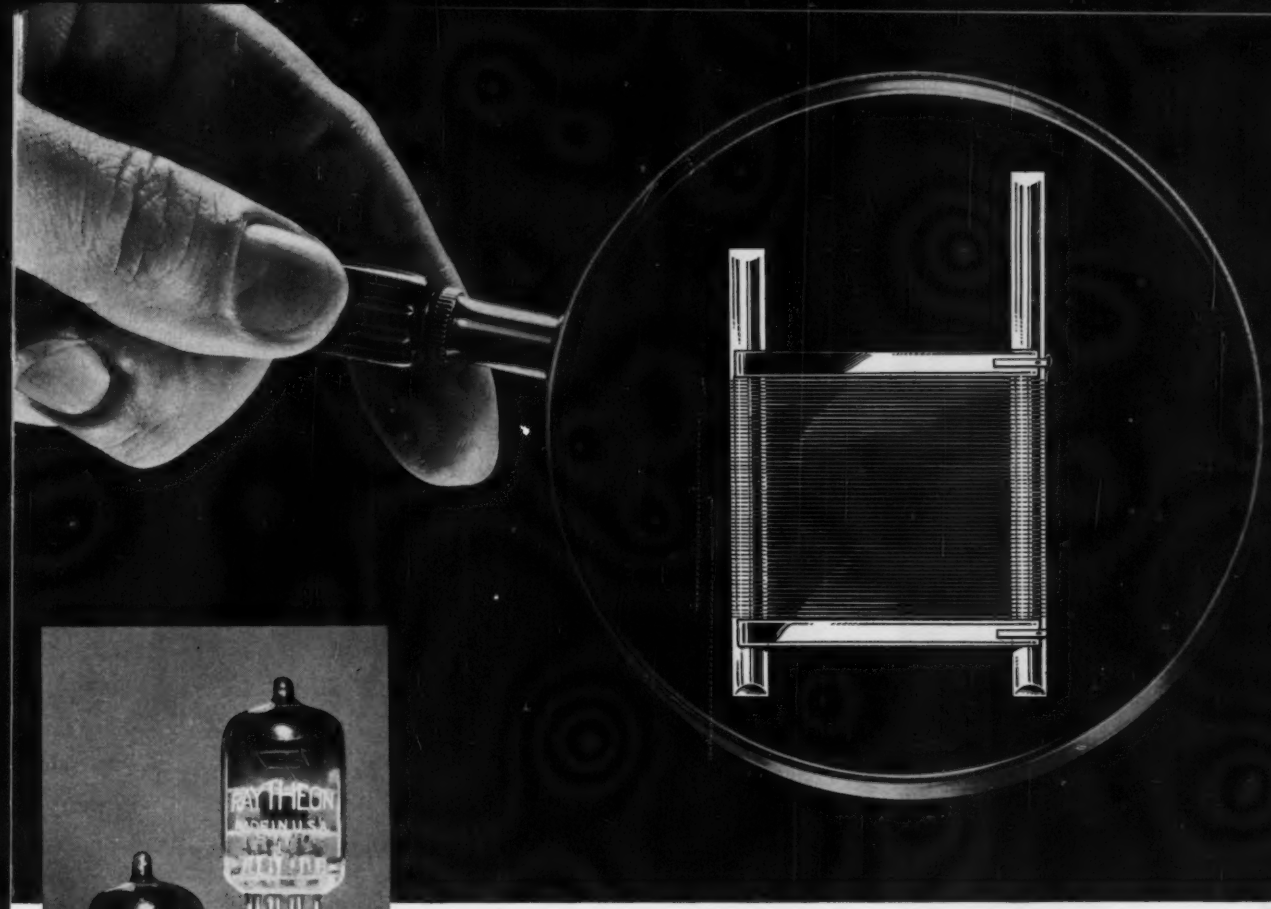
One method by which this might be accomplished has already been demonstrated. It involves incorporating an inexpensive standby circuit in transistor radios, to be operated by a special tone from a broadcast station. Receivers left in the standby position by their users would be automatically turned on, would emit a warning signal, and the station could then go on and tell the public what the warning was all about. This last-mentioned virtue could easily be just as important as the warning itself.

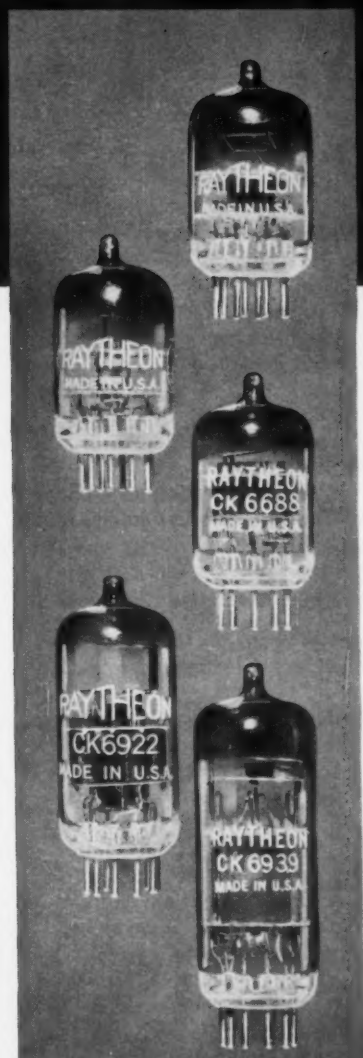
There are inherent weaknesses in any warning system, including radio. But they can be minimized. For example: To what station would the user tune his set? It could be tuned to either one of the two already established broadcast-band Conelrad frequencies. Turning the switch to the standby position could, in fact, automatically insure this. How many people would keep their standby circuits running and draining batteries even if these lasted several months? Sets equipped with the right kind of batteries and simple built-in chargers could be left plugged into the house circuit like clocks, and would continue to operate on the normally-floating batteries even after a power failure.

Think, also, of these virtues of a radio approach: The battery-operated set could be taken to a shelter after the warning to receive further instructions, which is already a recommended practice anyway. A radio system, because it could talk and instruct as well as give warning, could be used in purely local emergencies such as hurricanes. What about reliability of operation of the stations themselves? Many have emergency generators which would permit them to function for at least a little while even if power went out. And, finally, most homes could use another radio in normal times, particularly a portable.

Radio alarms, as a supplement to sirens, should be seriously considered before we plump for bells or buzzers as a matter of national policy.

CIRCLE 5 ON READER SERVICE CARD→





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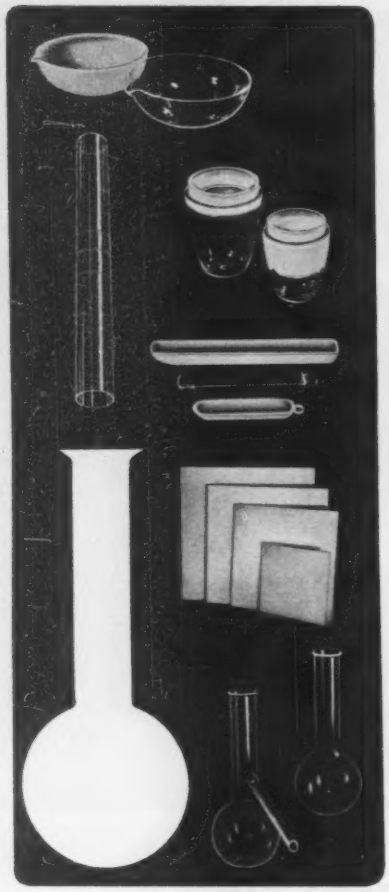

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Automatic Tube Tester

It was with considerable nostalgia that I read the article Automatic Tube Tester in the October 13 issue (p 82). A photograph of the "granddaddy" of all automatic testers is enclosed. It was taken in 1931 at the Majestic Radio Corporation in Chicago.

While the machine shown did not have test functions as elaborate as those shown in the recent article, the tests were sufficient for the tubes being produced at that time. This machine was jointly designed by the writer; Mr. Donald S. Bond, now at RCA in Camden, I believe; and Mr. Linn Sherk, a young and brilliant engineer who passed away long before his time. The foregoing were all reporting to Dr. Marvin Blackburn, also deceased.

The old machine contained some functions not even incorporated in this new one, with the sequence of tests as follows:

(1) Shorts: thirteen different possible combinations, any of which, would cause reject, and the type of short would show up and count at the control operator's desk area (not shown).

(2) Upper and lower plate current: tally upper and lower rejects.

(3) Screen current: tally rejects.

(4) Emission: tally rejects.

(5) Filament current and grid current: differentiate and tally rejects.

The tester also counted the incoming number of tubes, outgoing number of tubes, tallied all rejects and counted the number of empty sockets. It had a speed control on the rotor table to reduce speed, and a patchcord system to cut in a manual meter operation control until the defective control panel could be replaced.

There doesn't seem to be anything new under the sun, does there?

HAROLD E. WEST
Mallory Electromagnetic Company
Du Quoin, Illinois

Missiles, Space and Pipe Organs

Congratulations on the fine Missile and Space Electronics report (p 87, Nov. 17).

Nevertheless, I'm glad these topics did not crowd out pipe organs [Noise Generator Helps Create Pipe-Organ Sound Electronically, p 130]. I hope the phrase "have resulted in negative psycho-acoustic responses on the part of listeners" has some Basic English equivalent. No doubt the author wrote it with his tongue in both cheeks.

OTIS N. MINOT
Minot Informatic Devices
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The authors mean that the listeners experienced nonpositive reactions in their neuro-auricular sensory complexes. Or that they didn't like what they heard.

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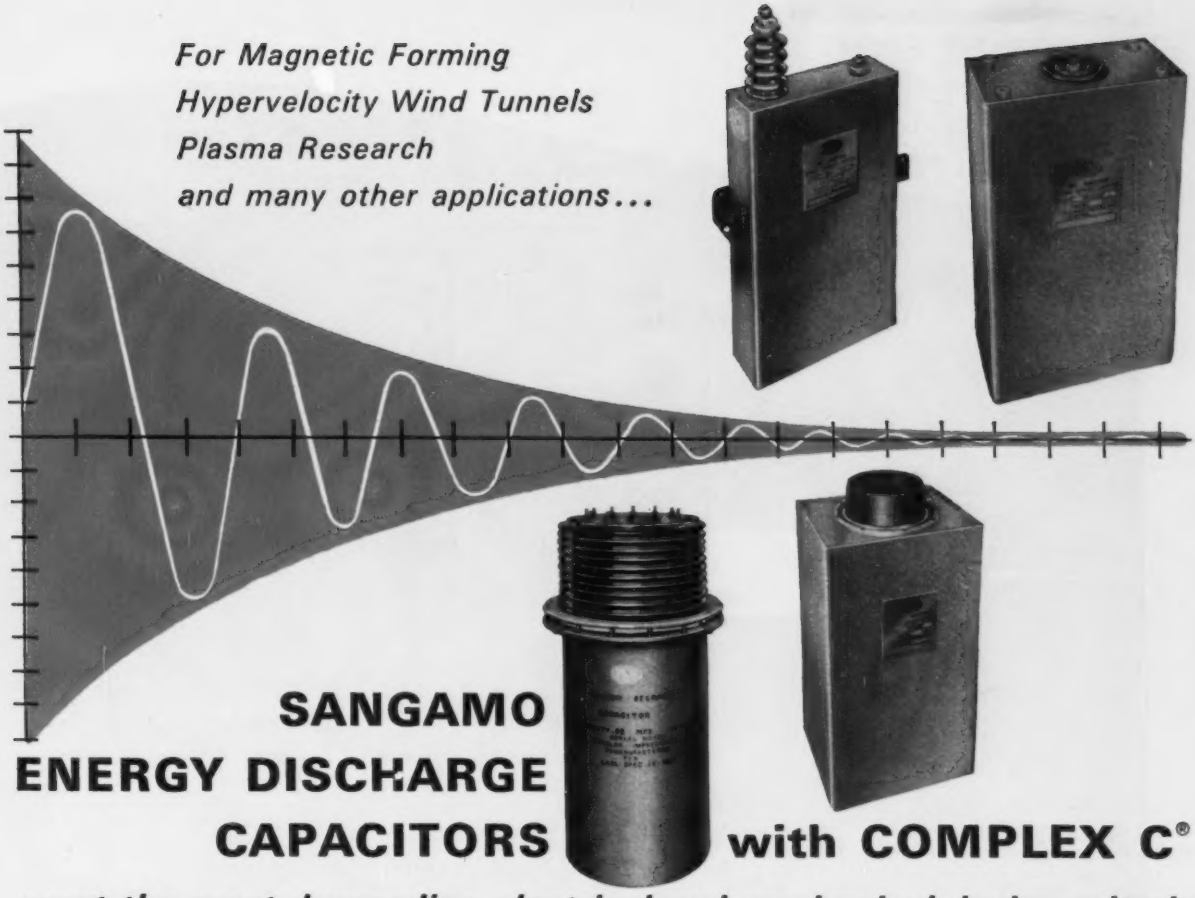
and many other applications...



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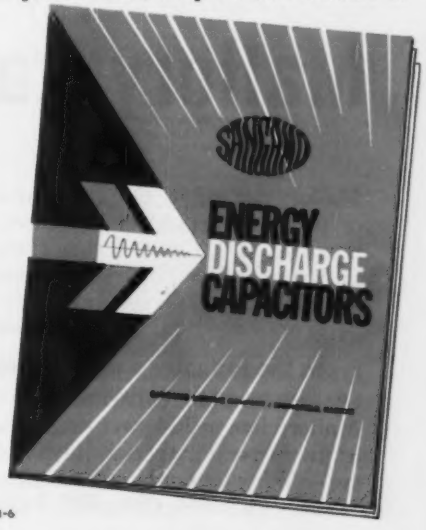

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EC61-6

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Type	Mallory Designation	Temp. Range	Case Style
PLAIN FOIL	Type TAF	—55°C to 85°C	CL34, CL35
	Type TAG	—55°C to 125°C	CL30, CL31
			CL32, CL33
ETCHED FOIL	Type TBF	—55°C to 85°C	CL24, CL25
	Type TBG	—55°C to 125°C	CL20, CL21
			CL22, CL23

Supplied in all military case styles and all ratings.

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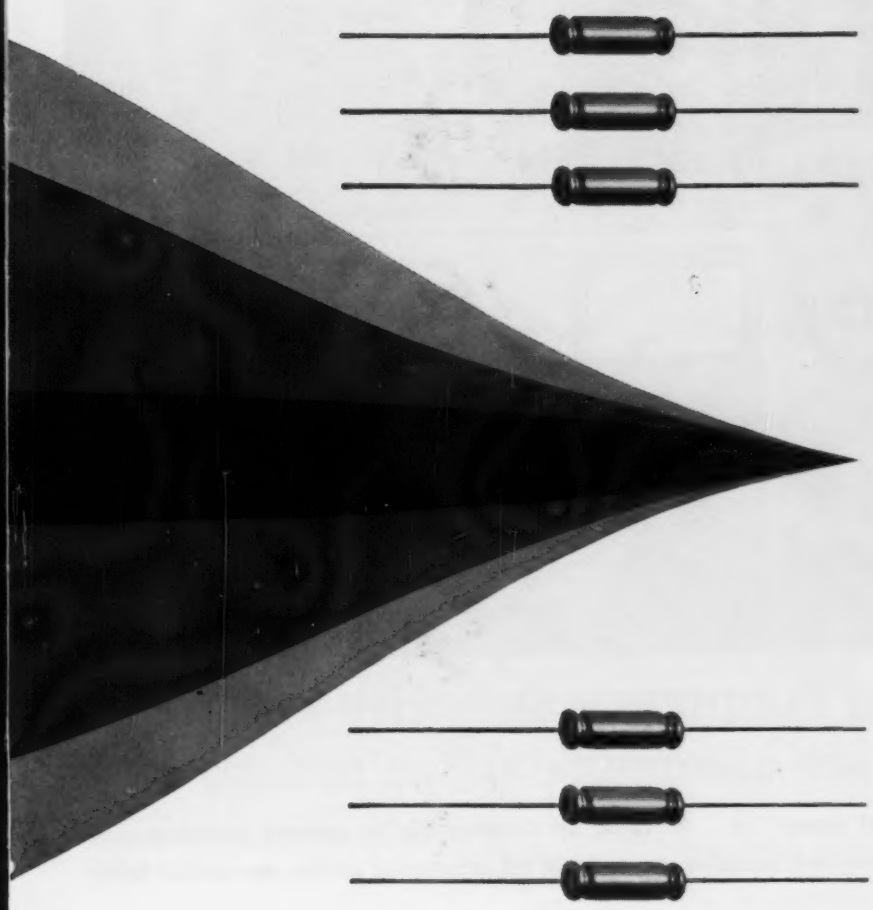

meet or beat MIL specs

	MIL-C-3965B Limits	Typical Test Values: Mallory Type TAF (160 mfd 15 VDC)
After 2000 hour life test at 85°C:		
Leakage Current	48 μa	0.4 μa
Change in Capacity	±25%	−5%
Power Factor	19.5%	3.8%
25°C:		
Leakage Current	48 μa	0.2 μa
Power Factor	15%	4.5%
−55°C:		
Change in Capacity	−35%	−12%
Impedance	14.0 ohms	7.0 ohms
85°C:		
Leakage Current	240 μa	6.5 μa
Change in Capacity	−0 +15%	+4.8%
Power Factor	15%	4.5%

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- Single frequency band, one continuous tuning range—eliminates band switching
- Flat voltmeter section—for accurate measurement, easy detection of spurious signals
- Wide bandwidth—1 to 620 kc—covers 120 channels per L carrier allocation
- Coarse, fine tuning on a single knob—for greater convenience
- Crystal controlled calibration oscillator—for checking both frequency and level
- Domestically produced—for years-ahead engineering, rugged construction
- Dual selectivity—versatility for communications test, wave analysis, general lab use

SPECIFICATIONS
MODEL 125A

Frequency Range
Tunable Mode: 3 kc to 620 kc
Flat Mode: 1 kc to 620 kc

Measurement Range
Tunable Mode: —90 dbm to +32 dbm
Flat Mode: —30 dbm to +32 dbm

Selectivity
Narrow: Down 3 db 125 cps off resonance; down 45 db 500 cps off resonance
Wide: Down 3 db 1.25 kc off resonance; down 45 db 5 kc off resonance

Price $895.00, f.o.b. factory

Call your Sierra representative or write direct. Sierra Model 125B-CR, with upper and lower sideband carrier re-insertion, and Model 125B-Y, with patchcord connections for type "O" and type "N" Western Electric carrier, also available at additional cost.

Data subject to change without notice.

sierra

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A Division of Philco Corporation
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Canada: Atlas Instrument Corporation, Ltd., Montreal, Ottawa, Toronto, Vancouver.
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7127

ELECTRONICS NEWSLETTER

Sage System Buildup Now History

TWENTY-FIRST and final Sage sector in the U.S. was turned over to Air Defense Command today in Sioux City, Iowa. Twenty-second direction center—the only one planned for Canada—will be built in Ottawa and is expected to be ready in two years.

Sage computer techniques are virtually frozen, but AF Electronic Systems Division at Hanscom Field, Bedford, Mass., is updating radar and identification techniques. Frequency diversity radar is being built into detection network for antijamming features, and ID techniques are getting increased channel and power capability. Systems program office at Bedford is also working on a backup system, which could operate even if some sector centers were wiped out by an enemy.

Sage system of coordinating radar data for continental defense against aircraft and airbreathing missiles is oldest of AF command and control systems, dating back to a 1949 study. MIT Lincoln Laboratory, set up in 1951 to design and develop Sage, handled system engineering until about three years ago when this went to Mitre Corp.

Sage-like system will probably evolve for air traffic control. Cost estimates on Sage range as high as $5 billion.

Air Force Steps Up 473L System Hardware Purchases

AIR FORCE Electronic Systems Division will brief industry Dec. 21 and 22 at Rome Air Development Center on phase 2 of 473L command and control system (ELECTRONICS, p 24, Apr. 21). The huge, complex system will automatically feed information from AF commands to Washington.

Bids will be invited on a data processing system for the Pentagon and integrated consoles with processing, display and communications controls. Four out of 15 consoles will be bought in this phase. Contracts to date have been largely for analyses and engineering, although Thompson-Ramo Wooldridge has sppplied display interface buffer and computer communications consoles, to be integrated with an IBM 1401.

In the next phase, financed in fiscal 1963, large panel displays and external message composers to be used at command sources will be bought.

ESD also announced a $48,000 contract to Sylvania for two prototype electroluminescent data displays for its global weather observation and forecasting system (433L).

'Twas Open Season on Big Radome in Maine

A 26-inch snowfall on the Bell Telephone System's nylon dome over the satellite experiment site in Andover, Maine, had local engineers worried. But shotgun slugs fired through the thin covering drained out the water.

Burdick W. Pierce, project engineer at the 13-story high radome, told a Portland men's club that the slug holes posed no problems since the inflatable structure has holes anyway which are covered with flaps to regulate the temperature.

A permanent radome of dacron and synthetic rubber was to be installed shortly. The first experimental satellite transmission of telephone and tv signals will be attempted in mid-April. He said the federal government will be paid $6 million to orbit a three-foot wide satellite into a 1,000-3,000 mile range.

Weekly Newsletter Bows

NEW YORK—The McGraw-Hill Publishing Company (publisher of ELECTRONICS) last week announced plans for publication of *Science Week*, a newsletter.

First issue will be published on or about Feb. 1. It will have six pages, 8½ by 11 inches, and be varityped, offset printed and illustrated

Supersonic Air Transport R&D Is Ready to Start

RESEARCH on a commercial supersonic transport is expected to get underway shortly, Aerospace Industries Association says. The Mach-3 aircraft could fly from New York to Los Angeles in 90 minutes.

Federal Aviation Agency has asked Air Force to let development contracts. The agency also recommended government participation in development costs, estimated at $550 million, AIA reported.

Air Force has been assigned contracts administration. FAA has over-all responsibility for the program, NASA and AF are to furnish technical support.

Most of the $11 million appropriated by Congress to start the project will be contracted for industry research.

Plug-In Neuron Devices Offered for Bionics R&D

PERCEPTIVE Research Products, of Yonkers, N.Y., reports it is making electronic neuron simulators for use as research and demonstration devices in bionics. The company says the neurons, developed at Bell Labs, closely simulate biological neuron properties of temporal summation, variable threshhold and refractory period, inhibition and pulse type output. Two models will be sold, a four-transistor model and a five-transistor version which more closely models the biological neuron.

ITT Shows Automatic Message Switching Center

AUTOMATIC data/message switching system is being offered industry by ITT Information Systems Division. This is reportedly a commercial version of the high-speed switching centers used in the Air Force 465L global communications network. The

system has a maximum capacity of four million bits per second. It can tie computers together for data exchange in different "languages." Provision is made for translating computer code.

ITT calls the system the ITT 7300 ADX (Automatic Data Exchange System). It operates on line in real time and is essentially a store and forward system.

Data can be dialed in to and out of the system over telephone lines. Other features are a message priority system, multiple addressing and limit to message length. Estimated price for a basic system is $1 million.

Rotating Pickup Pulses Auto Ignition System

MOTOROLA has unveiled an electronic ignition system for cars and trucks which uses a small magnetic pickup system instead of breaker points and condenser in the distributor.

The system is comprised of a magnetic pulse generator, a transistorized pulse amplifier and an ignition coil. The pulse generator is a small, spoked or toothed wheel which rotates past a tiny magnet without touching. Since there is no contact, there is no wear, adjustment, nor point chatter, Motorola says. The company announced an electronic alternator system a month ago.

Future Mercury Astronauts To Rendezvous in Space

NASA NOW PLANS to add $500 million to the Mercury program, to achieve rendezvous ability in space. Later Mercury vehicles will weigh between two and three tons and carry two men.

Meanwhile, the first manned orbital flight attempt has been postponed until after the first of the year while equipment malfunctions uncovered during the recent chimpanzee flight are cleared up.

Prelaunch problems on that flight included telemetering and communications link difficulties. During the two orbits, a transistor inverter overheated and an automatic control system failed to operate the hydrogen peroxide control jets, which resulted in the capsule orbiting out of alignment.

NASA said a few days ago that there had been a history of difficulties with the inverters, but that they were considered adequate for the flight. A larger inverter will be used on Lt. Col. Glenn's flight.

Philco, Now With Ford, Gets New Top Officers

FORD MOTOR CO. took over Philco Corp. as a wholly owned subsidiary on Monday, consummating a $100 million purchase agreement made in September (ELECTRONICS, p 11, Sept. 22). The new management said it had no plans to cut Philco's product lines.

New top officers were elected for Philco. Charles E. Beck, business planning director of Ford, is the new president and chief executive officer. He succeeds James M. Skinner, Jr., who resigned as Philco president. Irving A. Duffy, a Ford vice president and director, was elected chairman. Other new directors are also Ford executives.

Weathermen Get System To Measure Raindrops

METEOROLOGISTS who want to find out how big raindrops are can now use a sizer developed by New York University and the Army Signal Research and Development Laboratory. It automatically measures and counts raindrops in 13 sizes.

As the rain falls into the viewing system, images of the drops are projected onto a series of 14 horizontal plastic windows. Each window is separated from the next by a slightly larger gap and is connected to a multiplier phototube. When an image passes a gap as wide or wider than the drop, the size is noted. A memory unit stores the data and records it on punched tape for analysis.

The system may also be used to measure and count other small spherical objects.

In Brief . . .

NAVY has awarded three more atomic submarine contracts, bringing the total to 32, not including Polaris vessels.

INFRARED acquisition system for the Army's Mauler missile will be developed in Canada by De-Havilland Aircraft. Canada and the U. S. will share costs.

MINNEAPOLIS-HONEYWELL reports development of a 1-Kw transistor audio amplifier for submarine sonar.

COUNTERMEASURES contracts include $600,000 to Hallicrafters, for Nike Zeus, and $1.5 million to Loral, for a classified system.

AIR FORCE awards include $5 million to Lockheed for satellite control development; $2.3 million to Burroughs for aircraft equipment; $1 million to Hoffman Electronics for Tacan radio test sets, and $465,000 to Sylvania for tubes.

POLARIS contracts include a $4 million gyro production order to Minneapolis-Honeywell, and ground support equipment design, to Seigler, for the new long-range version.

MINUTEMAN ground equipment will be produced by Microlab and Hoover, under $200,000 and $135,000 subcontracts.

OTHER MISSILE contracts include $1 million to Belock Instrument for Hawk training simulators; $900,000 to Collins Radio for command-control destruct systems; $363,000 to American Concertone for recorders.

MARTIN-MARIETTA will soon test prototype pneumatic computers under R&D program aimed at low-cost, radiation-resistant, miniature guidance systems able to withstand 2,000 F temperatures. It also has $149,432 contract to study new intercept guidance techniques for missiles.

GENERAL ELECTRIC contracts for the Army's Advent communications satellite mount to $56 million with a new $8 million award.

new from NARDA!

- 4 to 1 Frequency Range
- Flat Coupling
- Accurate Tracking
- Extremely Low VSWR

high-directivity coax couplers

Specifically designed for REFLECTOMETER applications!

- Here are two brand new coax couplers, specifically designed by Narda to provide the extremely high directivity needed in Reflectometer set-ups. And when we say "extremely high directivity", we mean it! For example: Model 3020 (250 to 1000 mc) has a directivity of 35 db minimum, which means a maximum error in VSWR of only 1.035 can occur as a result of the finite directivity. Main line VSWR is held to 1.05 maximum; secondary line VSWR is 1.10 maximum!

- What's more, each model covers two full octaves; each features extremely accurate tracking (0.3 db maximum change in difference between forward and reverse coupling over the band); each has a power rating of 100 watts CW, 10 kw peak. Check the table for full specifications—and compare with any other units available.

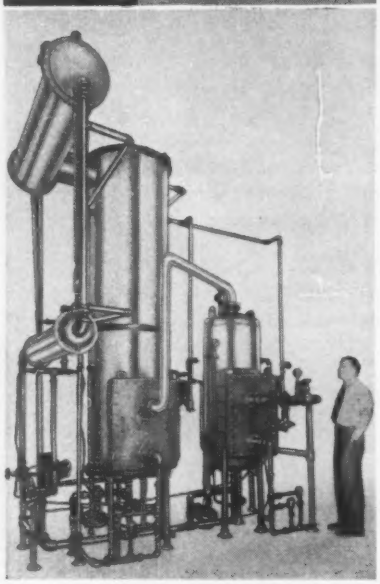
- These are just two examples of the complete line of unusually fine microwave and UHF instrumentation available from Narda. Write today for your free copy of our newest catalog. Address: Dept. E-1-4.

SPECIFICATIONS	MODEL 3020	MODEL 3022
Frequency	250 to 1000 mc	1000 to 4000 mc
Directivity	35db min	30db min
Coupling – both arms	20db nominal	20db nominal
– Frequency sensitivity	±0.6db approx.	±0.6db approx.
Max VSWR – main line	1.05	1.10
Max VSWR – secondary lines	1.10	1.15
Power Rating	100W cw 10kw peak	100W cw 10kw peak
Tracking	0.3db total	0.3db total
Price	$200.	$185.

the narda microwave corporation

PLAINVIEW, L. I., NEW YORK AREA CODE 516 GE 3-9000

B NEW



HIGHER WATER PURITY

NO OTHER STILL CAN MATCH WITH 50% LOWER STEAM COST

Reports Electronics Manufacturer

Recently installed in a large electronics manufacturing plant, this Barnstead Double-Effect Steam Heated Still not only out-performs an ordinary 200 gallon per hour Still but does it at 50% lower steam cost.

The water produced contains dissolved solids of less than one part in ten million and is free from bacteria, organics and particulate matter. This exceptionally high purity was made possible through the development of NEW Barnstead exclusive patented high purity features.

Full automatic controls not only reduced labor costs to a minimum but also eliminated the incidence of workmen's error. When you bring your water purification problems to Barnstead . . . you profit by 83 years of engineering experience encompassing most fields of manufacturing, processing and research. Write for New High Purity Bulletin #175.

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WASHINGTON OUTLOOK

LEGISLATIVE proposal to handle the controversial ownership problem of a worldwide communication satellite system has been prepared by the National Space Council for President Kennedy's approval.

The measure, to go to Congress early next year, will recommend against allowing international communications companies to dominate the system and calls for active public ownership, available to domestic and international interests.

It is now accepted that Congress will make the final decision on ownership of the communication satellite system. Hearings will be held by the Senate Aeronautical and Space Sciences Committee, chaired by Sen. Robert S. Kerr (D-Okla.). No date has been set.

TANTALUM, used in electronics for capacitors and high-temperature alloys, is having its biggest price boom in history. Tantalum ore prices have doubled since last September from $8.50 per pound, to around $17 a pound today. Tantalum scrap prices have doubled to $15 or $16 a pound, since the first of the year.

Cause of the price jump is primarily psychological, government metal buyers say. The Congo, the main U. S. source, was knocked out as a supplier by its political crisis. Last year, tantalum ore imports from the Congo ran about 31,720 pounds a month. Now, imports are less than 1,900 pounds a month.

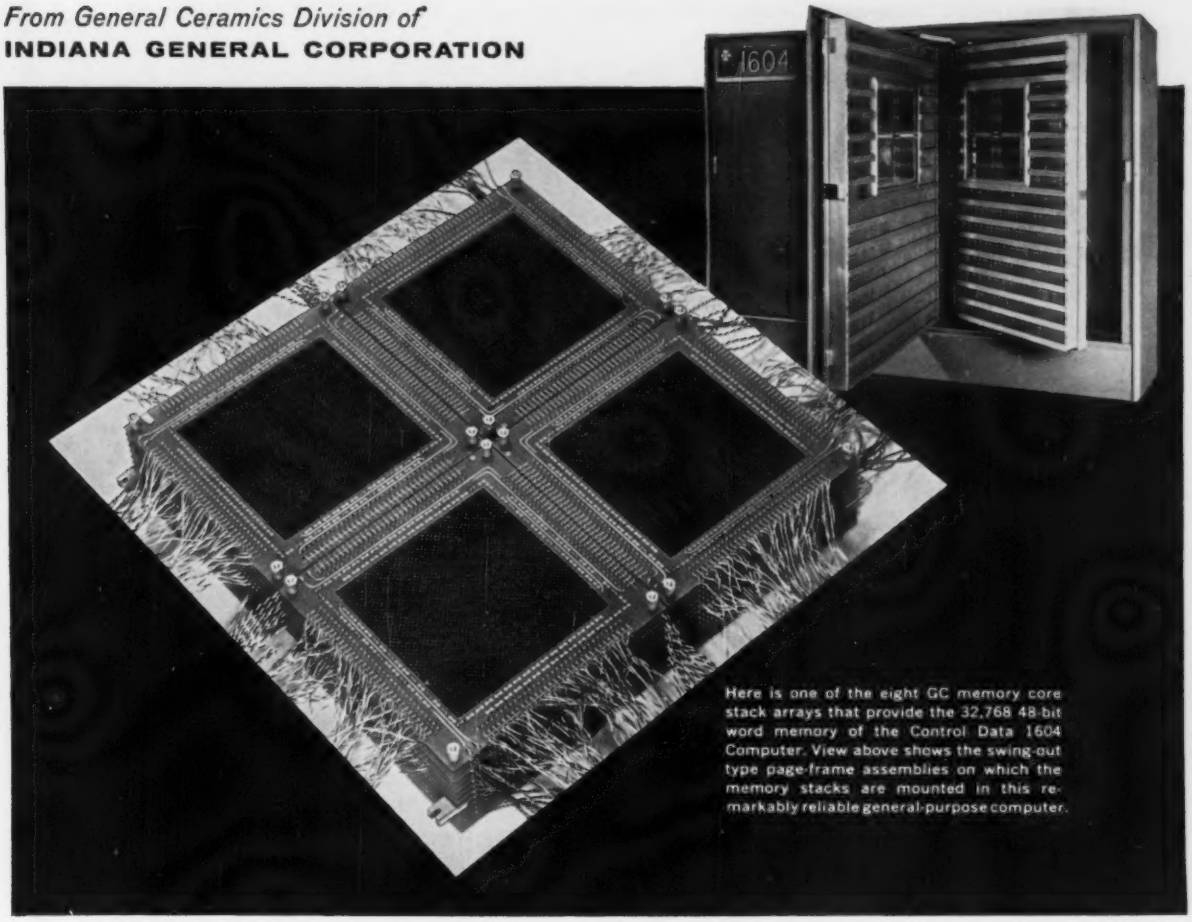
The rush for new sources has jacked up the price. Brazil is now coming in as a big tantalum supplier. So are Mozambique and Malaya. Tin slags and columbium ore containing tantalum are being imported in increasing quantities. Prices next year should be more normal.

PENTAGON is putting teeth into its program to increase rate of subcontracting to small businesses. Upcoming policy changes will (1) require subcontractors with orders of at least $500,000 to use small suppliers as much as possible, (2) require large firms to designate liaison executives to handle inquiries from small business suppliers, and (3) allow the Small Business Administration to check purchasing records of large prime military contractors—but only through channels (the procurement agency) —to check whether major defense producers are actually turning to small business on subcontracting.

But the new rules will not allow SBA the right to prescribe the extent of subcontracting nor to participate in administration of military contracts—provisions proposed by some congressional small business advocates.

TREASURY Department is making engineering studies of six major industries including aircraft (electronics is not specifically designated) to determine whether the legally prescribed useful life of production facilities can be shortened, thus accelerating depreciation for tax purposes. This follows recent decisions to liberalize depreciation policies for the textile industries and to spur new capital investment (ELECTRONICS, p 14, Nov. 3).

From General Ceramics Division of
INDIANA GENERAL CORPORATION



Here is one of the eight GC memory core stack arrays that provide the 32,768 48-bit word memory of the Control Data 1604 Computer. View above shows the swing-out type page-frame assemblies on which the memory stacks are mounted in this remarkably reliable general-purpose computer.

Reliability that Helps the **Control Data** 1604 Computer Achieve

"UPTIME" RATINGS THAT MEAN PROFIT

General Ceramics, the originator of the square loop ferrite, offers a complete line of job-proven cores, planes, stacks and memory systems — proven in many computer and control system applications where the ultimate in reliability is demanded.

A good example is Control Data's advanced, large-scale, solid state 1604 Computer which has set new reliability standards for the industry, maintaining one of the highest over-all average "uptime" ratings ever achieved for machines in its class. This high performance requires fail-proof output from every component, including the over 1.6 million GC cores wired into the memory stacks of the 1604.

According to W. F. Harrison, Control Data's Manager of Engineering Services, "GC was chosen on the basis of a careful evaluation which included criteria ranging from the supplier's reputation and background through his proven ability to produce required quantities with consistent quality."

General Ceramics reliability is assured through 100% quality control at all levels — beginning with mechanical and electrical testing of each individual core and continuing with both visual and electrical inspections at all stages of assembly. This means, for example, the meticulous microscope-checking of over 175,000 soldered connections alone in the eight banks of stacks used in each Control Data 1604 Computer.

Advanced techniques such as ultrasonic cleaning, automatic 12-per-second core testing and other electronic functional checks performed on specifically designed equipment provide that extra edge of quality which customers, such as Control Data Corporation, have come to expect from General Ceramics.

Compare GC with your present source — write, wire or phone today.

DIVISION OF INDIANA GENERAL CORPORATION

APPLIED LOGICS DEPARTMENT

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To Contractors and Subcontractors on U.S. Government Projects

NEW TRANSISTOR 2N1645

■ HIGH RELIABILITY ■ ONE WATT POWER OUTPUT AT 100 MC/S
■ EFFICIENCY APPROXIMATELY 50%

The 2N1645 is a diffused base germanium mesa transistor for UHF power amplifiers, frequency multipliers, and very high speed, high current switching applications. Typical turn-on and turn-off times under constant voltage drive conditions are less than 5 and 15 nanoseconds respectively. Power output of one-half watt as a doubler may be achieved up to 250 megacycles.

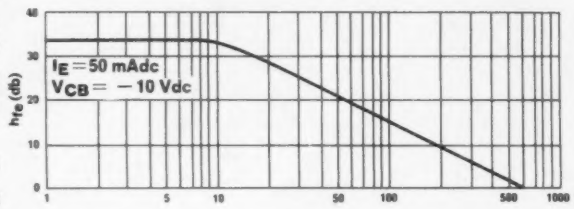
MAXIMUM RATINGS AT 25°C

Collector Current	300 mAdc
Collector Voltage	35 Volts
Emitter Voltage	1 Volt
Junction Temperature	100°C
Power ($T_A = 25°C$)	1 Watt
Power ($T_C = 25°C$)	6 Watts

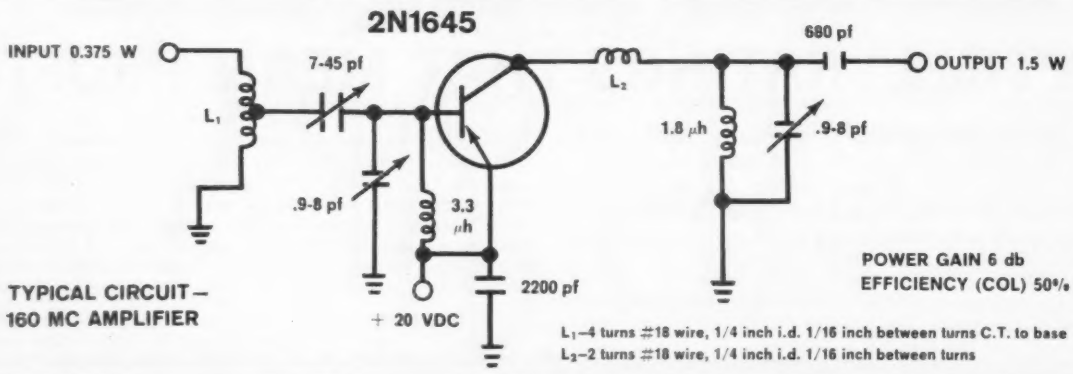
TYPICAL ELECTRICAL CHARACTERISTICS

f_t	600 mc
REh_{ie} (250 mc)	23 ohms
C_{cb} (dir)	10 pf
h_{fe} (1000 cps)	50
h_{FE} ($I_C = 100$ mA)	35

TYPICAL CURRENT GAIN VS FREQUENCY



FREQUENCY IN MEGACYCLES



The 2N1645 transistor may be purchased in quantity from Western Electric's Laureldale Plant. For technical information, price, and delivery, please address your request to Sales Department, Room 102, Western Electric Company, Incorporated, Laureldale Plant, Laureldale, Pa. Telephone—Area Code 215—WAlker 9-9411.

LAURELDALE PLANT

Western Electric
MANUFACTURING AND SUPPLY UNIT OF THE BELL SYSTEM

Project Surveyor engineering openings

Hughes Space Systems Division has immediate openings for Electronic Engineers, Mechanical Engineers, Physicists and Aeronautical Engineers to work on Project Surveyor—a spacecraft which will soft land on the moon. Once there, Surveyor instruments will perform a variety of scientific tests: drills will pierce and analyze the moon's surface; high quality television pictures will be transmitted to earth; other instruments will measure the moon's magnetic and radiation characteristics. ■ To accomplish this step into space, Project Surveyor requires the talents of imaginative junior and senior engineers and scientists to augment its outstanding staff. Experience is preferred but not required. A few of the openings include:

control engineers

Concerns hydraulics, airborne computers, and other controls related areas for: missiles and space vehicles, satellites, radar tracking, control circuitry, controls systems, control techniques, transistorized equalization networks and control servomechanisms.

circuit designers

Involves analysis and synthesis of systems for: telemetering and command circuits for space vehicles, high efficiency power supplies for airborne and space electronic systems, space command, space television, guidance and control systems, and others.

systems analysts

To consider basic problems such as: the requirements of manned space flight; automatic target recognition requirements for unmanned satellites or high speed strike reconnaissance systems; IR systems requirements for ballistic missile defense.

infrared

Includes systems analysis and preliminary design in infrared activities involving: satellite detection and identification; air-to-air missiles; AICBM, infrared range measurement; air-to-air detection cryogenics and others.

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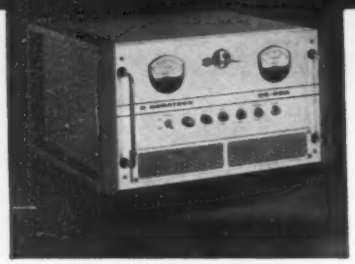


PRECISION REGULATED TRANSISTORIZED DC SUPPLY

Tubeless circuitry, regulation of ±0.05% line and load combined and an output voltage range of 4.5 to 9.0 V DC are features of the Sorensen Model Q6-60A. Output current range is 0 to 60 Amps. and ripple is 0.5 MV at nominal output voltage ±10%. The Q6-60A is completely self-protected and particularly suitable for critical applications requiring "spike free" output, precise regulation and high currents.

DC POWER SUPPLY

0 to 40 V DC at 0 to 2 Amps.

The new versatile, fully transistorized QR40-2A DC Power Supply incorporates all the basic features of Sorensen QR Supplies. In addition, it provides regulated current, adjustable current limiting, and programmed output voltage. Provisions for external sensing permit accurate voltage regulation at remote loads. Available for either standard 19-inch rack mounting or in self-contained cabinet, the QR40-2A will easily adapt to your requirements. Write for complete specifications and literature on this dependable, economical power supply.

SPECIFICATIONS

INPUT VOLTAGE RANGE	105-125 at 50 to 400 cps.
DC OUTPUT VOLTS	0 to 40 V DC
DC OUTPUT CURRENT	0 to 2 Amps. DC
VOLTAGE REGULATION (Line & Load Combined)	±(0.01% + 1 MV)
RIPPLE (RMS) AT 60 CPS.	150 Microvolts
CURRENT REGULATION (Line & Load Combined)	±0.15%
RIPPLE CURRENT	30 Microamps.
RESPONSE TIME	50 Microseconds
CABINET SIZE	17"x12⅛"x6¼"
RACK HEIGHT	5¼"

A UNIT OF RAYTHEON COMPANY

Sorensen

RICHARDS AVENUE • SOUTH NORWALK • CONNECTICUT

CIRCLE 18 ON READER SERVICE CARD

NEW FROM SORENSEN

Compact
Fully Transistorized

DC POWER SUPPLY

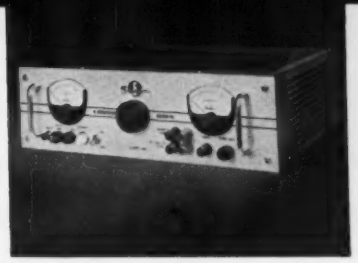
0 to 40 V DC at 0 to .75 Amp.

The compact new Sorensen Model QR40-.75A is one of the latest additions to Sorensen's line of outstanding products. It features extremely low ripple, precise regulation, programmable output voltage, adjustable current limiting and provisions for remote sensing. Typical applications include powering computer circuits, test and instrumentation equipment, and communications equipment. Negligible on-off overshoot provides protection for transistor circuits. Write for complete specifications and literature.

SPECIFICATIONS

INPUT VOLTAGE RANGE	105-125 V AC at 50-400 cps.
DC OUTPUT VOLTS	0 to 40 V DC
DC OUTPUT CURRENT	0 to .75 Amp.
VOLTAGE REGULATION (Line & Load Combined)	±(0.01% + 1 MV)
RIPPLE (RMS) AT 60 CPS	150 Microvolts
CURRENT REGULATION (Line & Load Combined)	±0.15%
RIPPLE CURRENT	10 Microamps.
RESPONSE TIME	50 Microseconds
CABINET SIZE	8¼" x 9" x 5¼"
RACK HEIGHT	5¼"

Unit is available for dual rack mounting



WIDE RANGE
TRANSISTORIZED DC SUPPLY

The QR150-1A is a completely self-protected, transistorized DC Power Supply. Output voltage range: 0 to 150 V DC at 0 to 1 Amp. output current. Combined line and load regulation is ±(0.02% + 4 MV). Ripple is 1 MV RMS. *Circuit Design and protective features prevent damage to transistors under overload or short-circuit conditions.*

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RICHARDS AVENUE • SOUTH NORWALK • CONNECTICUT

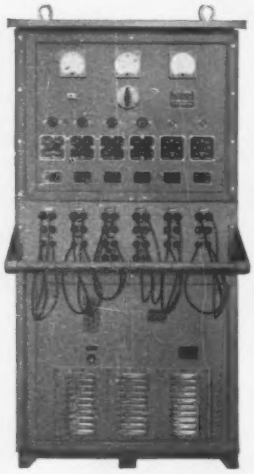
CIRCLE 19 ON READER SERVICE CARD

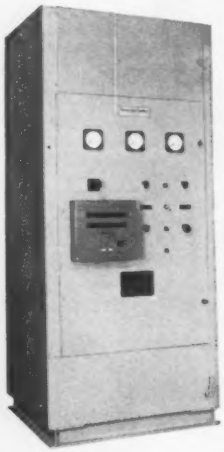
Acme Electric

CUSTOM BUILT POWER SUPPLIES

These units are engineered to provide specified electrical characteristics in a practical physical design and to perform properly under a wide range of environmental conditions.

Our facilities can accommodate continuous production quantities as well as small lots.





ABOVE — STATIC POWER RECTIFIER
Output: 500 KW, 500 volts DC 1000 amperes
Input: 13,800 volts, 33 amp. 3 phase, 60 cycle

ABOVE — 6 CIRCUIT POWER SUPPLY
Output: 4 circuits, 45 amp, 65 volt DC
2 circuits, 1-8 amp, 65 volt DC
Input: 460 volts, 3 phase, 60 cycle

RIGHT — MODULE ANALYZER
Output: − 6.5 + 6.5 − 13 + 13 — 19.5 + 48 — 48 volts DC
Input: 115 volts, single phase, 60 cycle

Our vast store of engineering experience is available to assist you in developing a practical solution to your problem.

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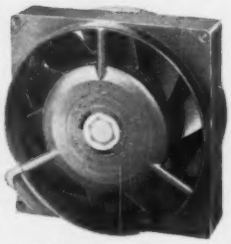
Acme ACME Electric

New! MINIATURE AXIAL FANS with up to 4 times greater cooling efficiency!



Characteristic	PAMOTOR Model 1000	Conventional Fan
Type of Motor	induction (capacitor-type squirrel cage)	shaded-pole
Housing	die cast warp-free Zymec	plastic
Output @ 60 cps (0 back pressure) (.25" back pressure) (.3" back pressure)	125 cfm 75 cfm 50 cfm	100 cfm 20 cfm 0
Output @ 50 cps (0 back pressure) (.25" back pressure)	100 cfm 62.5 cfm	75 cfm 5 cfm
Operating Temp. Range	−55°C to +85°C	−18°C to +44°C

The PAMOTOR Model 1000 Miniature Fan is completely interchangeable with conventional units now in use (4⅛" center-to-center mounting holes). But the similarity ends there.

check this comparison chart!

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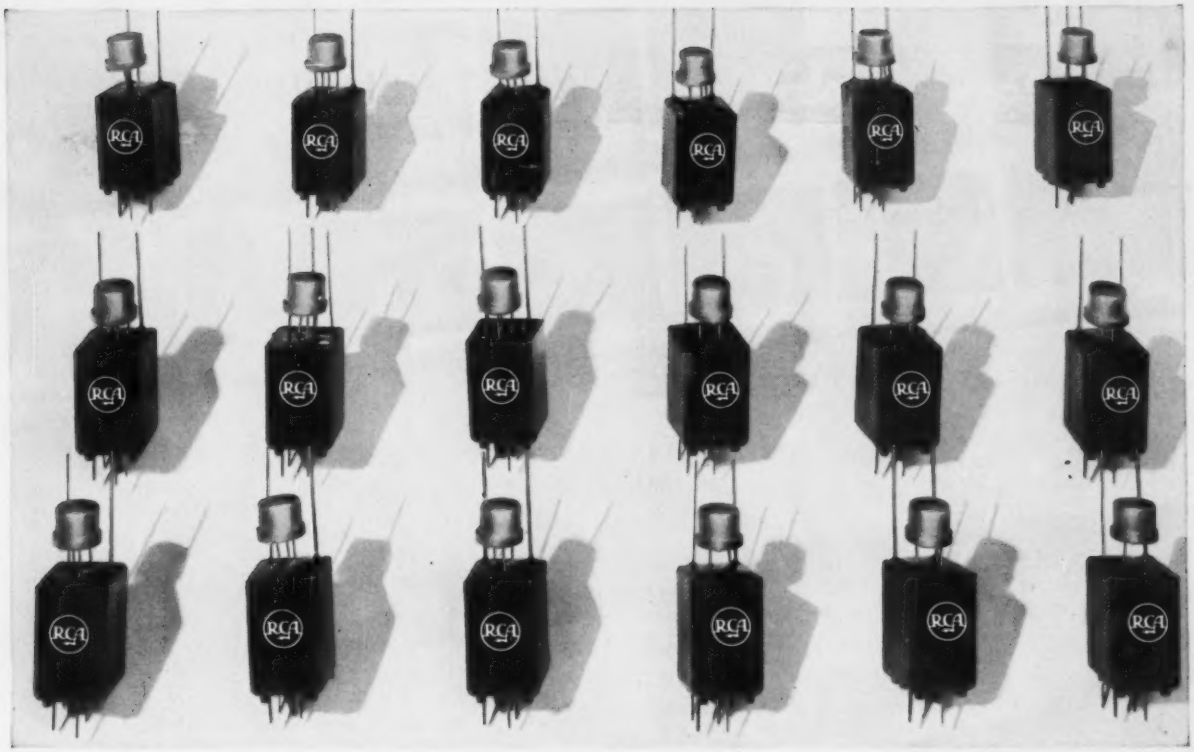

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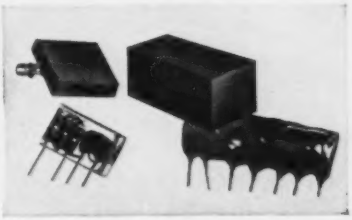

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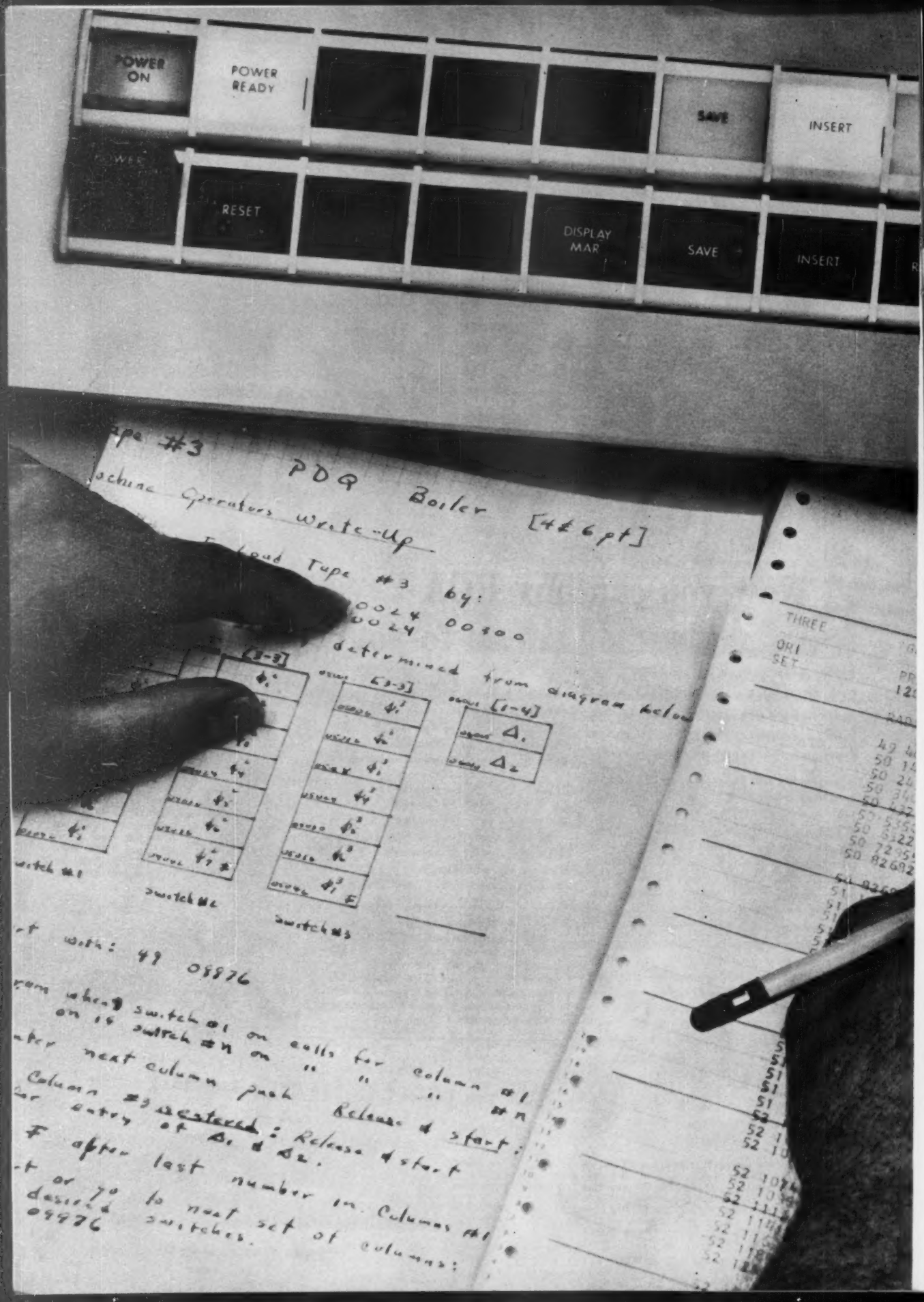
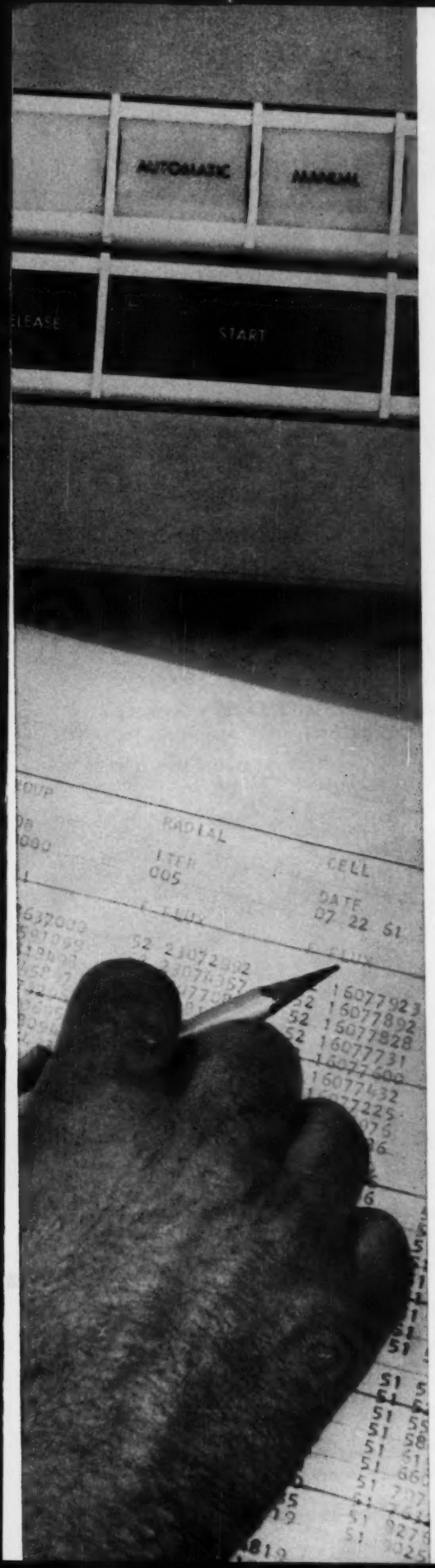

POWER ON
POWER READY
SAVE
INSERT
RESET
DISPLAY MAR
SAVE
INSERT
pe #3
PDQ Boiler [4 & 6 pt]
chine Operators write-up
Load Tape #3 by:
0024 00400
0024
determined from diagram below
[3-3]
[3-3]
[1-4]
switch #1
switch #2
switch #3
with: 49 0887G
from when switch #1 on calls for column #1
on if switch #n on " " " #n
after next column push Release & start:
Column #3 entered: Release & start
for entry of Δ1 & Δ2.
If after last number in Columns #1
or 70 to next set of columns:
desired
0887G switches.
THREE
ORI
SET



Cost of one-dimensional criticality computations drops from an average of $75.00 to $7.50 per problem

Faster computing, less travel time are the reasons why General Nuclear Engineering Corporation has realized such cost savings since it installed an IBM 1620 Data Processing System at its Dunedin, Florida plant.

Since its main computing facilities are not located at Dunedin, General Nuclear has found that the new 1620 eliminates much of the travel time and expense involved in taking problems to off-site computers. In addition, the 1620 performs the simpler criticality computations 10 times faster than the computer previously used at one of General Nuclear's off-site data processing centers.

General Nuclear uses its new 1620 for other problems, too...heat transfer calculations, various transient codes, mathematical routines for the physics and engineering departments, multi-group calculations, and many other jobs you might expect only a much more expensive computer to be able to handle.

This isn't all. General Nuclear uses the 1620 to do statistical analyses and variance calculations on input data for programs run on off-site large-scale IBM computers.

For information on this highly versatile, low-cost data processing system, which rents for as little as $1600 a month, contact your local IBM Representative.

Easy to program. FORTRAN, IBM's scientific computer language is available for the 1620. General Nuclear scientists use a special scientific interpretive program—FIDO—written by the Manager of their Computing Section.

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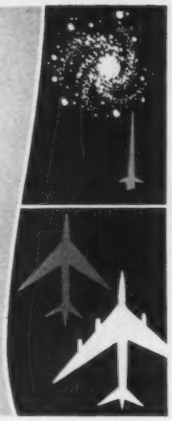
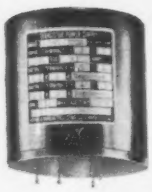


DC TO SINE WAVE *Model KB* (Stock Item)

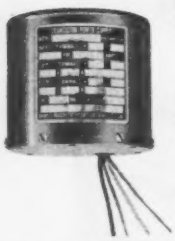
Input Voltage: . . . . 24-30 VDC
Output Voltage: . . . . 115 VRMS
Output Frequency: . . . . 400 cps (other frequencies available)
Output Power: . . . . 50 volt-amps
Frequency Regulation: 0.3% for 6 V line variations
Harmonic Distortion (Total): 2% at specified load (4% max.)
Size and Weight: . . 2½"x4"x2½" high; 26 oz.

DC TO DC *Model 591HC*



Input Voltage . . . . 24-30 VDC
Output Voltage Range . from 6 VDC to 3500 VDC
Output Power . . 60 watts (max.) regulated
Regulation . . ±1.0% for 6 V line variations; ±1.5% for 50% load variations
Ripple . . . . . 0.3% RMS
Size and Weight . 3" OD x 3⅛" high; 22 oz.

DC TO SQUARE WAVE *Model 591ACB*



Input Voltage . . . . 24-30 VDC
Output Voltage Range . 1.0 to 3500 VRMS, square wave, 400 cps (other frequencies available)
Output Power . . . . . 50 V. A.
Regulation . Frequency and Voltage: ±1.0% for 6 V line variations; ±1.0% for 50% load variations
Size and Weight . . 3" OD x 3" high; 19 oz.

Constant frequency, voltage and output as battery discharges. Units withstand short circuit, reversed polarity and input voltage transients of 60 volts. Load power factors as low as 0.2 (lead or lag) may be applied.

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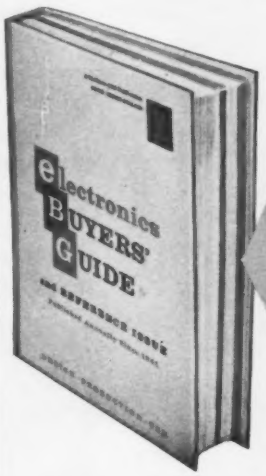

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ONE OF THE MOST VITAL *equipment needs today and for the future is improved range instrumentation. More specifically: "The single most difficult task facing the range instrumentation engineer today is acquisition of high quality trajectory data during the boost and orbital phases."*

This statement was made at the American Rocket Society meeting in New York in a paper by R. V. Godfrey of Pan American World Airways, Inc., which operates the Atlantic Missile Range for the Air Force, and C. L. Carroll of Aerospace Corp.

High quality data are needed to obtain real-time impact prediction for missiles, to establish orbital parameters for satellites and trajectories for manned and unmanned space probes, and—for the R&D engineer—to identify and isolate inertial guidance system errors.

Besides c-w interferometric tracking systems, such as Azuza I and II and the newer Mistram (ELECTRONICS, *p 38, July 28, 1960; p 109 Nov. 17, 1961), pulse radar systems are moving forward at a healthy pace.*

The C, L and X band radars Sperry is developing for the two converted C-4 troop carrier ships are believed to have impressive range capabilities (ELECTRONICS, *p 22, July 28, 1961). Advanced radar under development for later ships in USAF's Mobile Atlantic Range Stations (Mars) program will have even greater skin tracking capabilities. First Mars ship will be operational next fall. More ships will follow.*

RCA is developing, in-house, a long-range tracking radar, a real-time tracking technique for off-the-launch-pad trajectory measurement, laser radar techniques and global-range integration techniques

NEW PULSE TRACKERS Readied

BY SEPTEMBER, a new pulse radar will be operational at the Atlantic Missile Range. It will mark a significant jump beyond pulse trajectory measurement systems now in operation at U. S. missile ranges. Designated AN/FPQ-6, the new radar will be capable of nonambiguous range measurement of targets up to 32,000 nautical miles.

The AN/FPS-16 (now in use), out of which FPQ-6 was evolved, was built for nonambiguous range measurement of targets up to 500 n.mi. A digital range modification kit now in use at the Pacific Missile Range and ready for use at the Atlantic Missile Range (AMR), extends the nonambiguous range measurement capability to somewhat over 8,000 n.mi.

Both the FPS-16 and the FPQ-6 are capable of simultaneous presentation of returns from regular radar echo (skin) targets and from beacon-carrying targets. Although the radars will track returns having negative signal-to-noise ratios, the usual practice is to quote ranges to the zero db signal-to-noise ratio condition to establish a reference point.

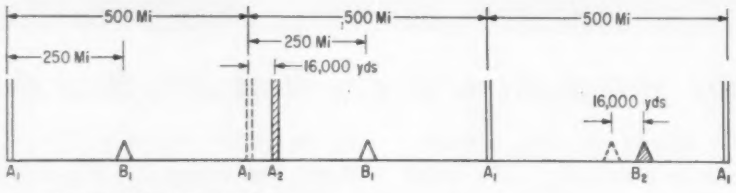
Using this reference, the FPS-16 will skin track targets having an effective radar cross section of one square meter to about 125 n.mi. The new FPQ-6 will extend this tracking range to 500 n.mi.

The range of either radar on beacon-carrying targets depends upon the characteristics of the beacon in the target and upon its antenna pattern. Beacon tracks are normally established to ranges many times beyond the skin tracking capability and could conceivably exceed the nonambiguous measurement capabilities of the radars.

Later FPQ-6s may be beefed up in several ways. To quote a few possibilities: (1) parametric amplifiers would extend the one square meter range to 650 nautical miles; (2) use of one of the simpler versions of pulse compression techniques, 850 n.mi; (3) use of (1) and (2) together, 1,100 n.mi; and (4) a cryogenic version of (1) plus doubling the transmittal power of (2), 1,850 n.mi.

RCA's Missile and Surface Radar division built the FPS-16 and is now producing the FPQ-6 under contract to the Navy Bureau of Weapons. The first two FPQ-6s will be delivered to the Atlantic Missile Range and be checked out and operational by September. A transportable version, designated TPQ-18 that can be packed in nine shelters and transported in C-124 or C-133 cargo planes or by ship, will be delivered to AMR already checked out and ready to operate in August.

New features used in the FPQ-6, according to RCA, include: a revised console to provide the most useful acquisition features for the operators as well as automatic, semiautomatic and manual equipment to supplement the operators; improved built-in acquisition features in the ranging equipment; an auxiliary nonreferenced range system (Auxtrack) which permits



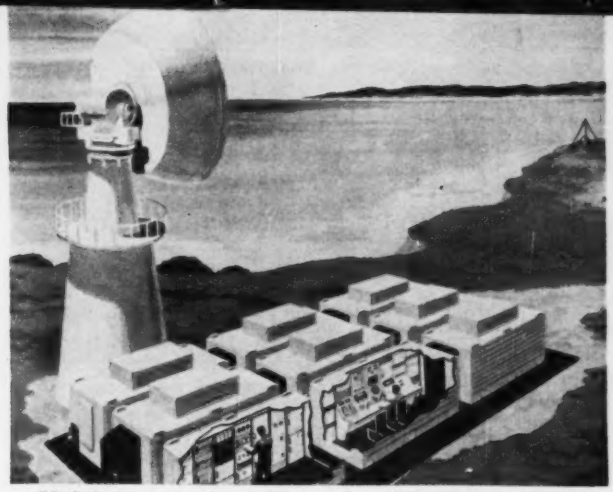
A_1 – REGULAR PULSE TRANSMISSION

B_1 – ECHO FROM A PREVIOUS A_1 PULSE TRANSMISSION

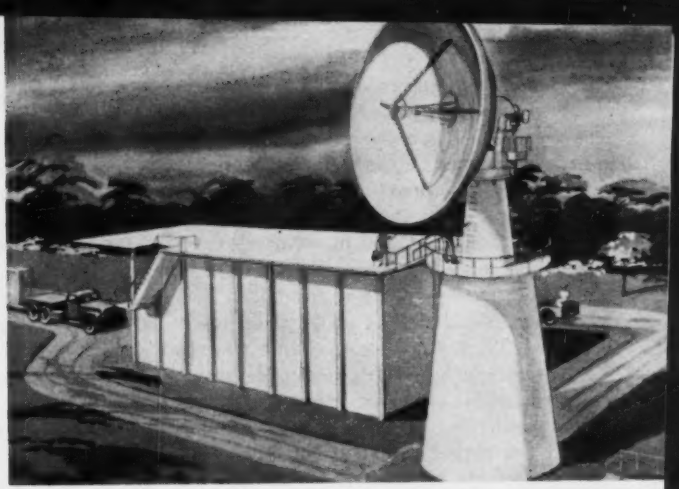
A_2 – DELAYED PULSE TRANSMISSION, 16,000 yd AFTER NORMAL TIME

B_2 – ECHO FROM THE FIRST A_2 PULSE TO BE TRANSMITTED, ONE ZONE BEHIND

FPQ-6 determines true range of target by placing it in a zone. In this example, target in second zone has apparent range of 250 n. mi, true range of 750 n. mi



Modularized transportable version, AN/TPQ-18, can be moved by land carrier or cargo aircraft



Permanent AN/FPQ-6 installation to meet tighter range requirements, nonambiguous tracking to 32,000 n. mi

For Space Ranges

By JOHN F. MASON, Associate Editor

angle-only acquisition and tracking through operator selective gating of the tracking receivers; a C-scope with video integrator to enhance long range target acquisition; rapid slewing circuits (on the order of several hundred thousand yards per second) with added tracking features; and four A scopes displaying range increments.

The transmitter is a more stable version of the one developed several years ago for the Signal Corps and White Sands Missile Range. It is convertible to doppler measurement (target radial range rate), pulse compression, and other more elaborate coherent transmitter-receiver techniques. The transmitter frequency synthesizer and multiplier scheme may be used with minor variations to drive r-f output stages covering other r-f frequency bands, such as L, S or X band.

The digital range machine that has extended the nonambiguous tracking range to above 32,000 n.mi was originally developed as a modification kit for the FPS-16. As far as is known, RCA says, this is the only range tracker in the world with nonambiguous, multiple time around tracking capability to this range. The multiple time around feature permits the use of much higher repetition rates than could otherwise be utilized. It is all-electronic and prevents beacon-stealing. This feature is vital to multiple station radar operation with overlapping radar coverage.

The trick to measuring nonambiguous range at such a distance is to be able to determine which transmitted pulse has created the echo that appears on the scope. For example, a pulse repetition frequency that allows a pulse to travel to a target 500 n.mi away and return before the next pulse is transmitted will present any target within this 500 mi range without ambiguity.

If, however, a target is 750 mi from the transmitter, a second pulse will have been transmitted before the echo from the first pulse has returned. The 750-mi target will appear on the scope as 250 mi. To obtain its true range, it must be determined which zone the target is in. Its true range will be the 500 mi across zone 1 plus its apparent range of 250 mi, totaling 750 mi. A target at 1,250 mi true range—in zone 3—would still present an apparent range of 250 mi.

When a target is acquired with

INSTRUMENTATION RADAR CHARACTERISTICS

System	FPS-16 (1955)	FPQ-6 (1961)
Frequency	5,400–5,900 Mc	C-band tunable 5,400–5,900 Mc
Peak power	1 Mw fixed; 250 Kw tunable	3 Mw
Pulse repetition frequency	various, between 142 & 1,707 pps	160 & 640 primary but others up to 1,707 pps
Pulse duration with pulse coding	0.25, 0.5 & 1 μsec	0.25, 0.5, 1 & 2.4 μsec
Antenna beam width	1.1 deg	0.4 deg
Receiver noise figure	10 db	8 db
Range measurement capability	500 n. mi; 8,000 with digital range modification	32,000 n. mi, nonambiguous
Range tracking granularity	1 yd	2 yd
Antenna size	12 ft; 4-horn monopulse	29 ft cassegrainian 5-horn monopulse feed
Antenna gain	44.5 db	51 db
Antenna polarization	vertical	vertical or circular
Antenna pedestal weight	12,000 lb	100,000 lb
Angle tracking rates	az 40 deg/sec; el 30 deg/sec	up to 28 deg/sec/in. both axes
Angle tracking precision	0.1 mil rms	0.05 mil rms
Range tracking rates	10,000 yd/sec	20,000 yd/sec

no previous reference some technique must be used to determine its zone. Here, in principle, is how the FPQ-6 does it automatically:

In the drawing, a target is acquired (B_1) establishing an apparent range of 250 mi. On the next go-round, the transmitter pulse is delayed by 16,000 yards (A_2). Two receiver tracking gates are generated simultaneously, the first to coincide with the regular pulse at the target's apparent range, and the second for the delayed pulse return.

A target echo appears again. If this echo appears from the delayed pulse, then the target is actually 250 miles away. In the example, however, the return appears from a normal transmission. This indicates that the target is at least more than one zone away.

On the next go-round, a delayed echo (B_2) appears. This tells that the target is in zone 2. The true range is then 750 mi.

The zone number is thus obtained by counting the number of times the pairs of tracking gates are generated before a target return appears in the second gate. The true range is the number of zones minus one, plus the apparent range.

A problem arises from this zone identification technique. As the target moves from one zone into the next, tracking may be lost due to receiver saturation or ground clutter. The solution is to prevent the target signal's being returned in an interference region. This is done by alternately delaying groups of transmitter pulses and receiver tracking gates by 32,000 yds until the signal return is outside the interference region.

The antenna mount is probably the greatest single contributor to the successful performance of the radar, RCA says. Features included are precise data takeoffs; high and low servo response bandwidth capability with high gain across the variable range; high torques to counteract wind forces and to achieve high accelerations; hydrostatic bearing in azimuth and phased ball bearings in elevation to provide tracking smoothness at extremely low, as well as high, angular velocities; attention to maintaining the orthoganality of the azimuth and elevation mechanical axes; and minimization of changes in a stability due to thermal effects.

Silver Price Jumps Nine Cents

WASHINGTON — Kennedy administration changes in silver policy, to reestablish a free market, has caused initial wide fluctuation in the world price. As predicted (ELECTRONICS p 14, Oct 20), world price almost immediately went over $1 an ounce.

The Treasury stopped selling at 91 cents an ounce. This price, two cents under world price, had caused its free silver stock to dwindle from 210 million ounces in 1959 to 22 million.

Treasury estimates world demand at 300 million ounces and supply at 235 million. Demand will be lowered to 250 million ounces by having the Treasury draw on paper money reserves for its 50-million-ounce annual coinage requirements.

The administration wants Congress to repeal the mandatory buying price of 90.5 cents for new silver and to remove the 50 percent tax on silver transaction profits. Congress will probably go along, but senators from silver-producing states are expected to put up a fight.

Sen. Frank Church, of Idaho, a leader of the silver bloc, has predicted price will stabilize around $1.10. He feels this price, plus restoration of a free market in the U. S., will stimulate production enough to close the gap between supply and demand.

Spokesmen for the Silver Users Association contend narrowing the gap and removing the profits tax will bring significantly larger amounts of silver—both new silver and hoarded—on the market. They estimate the world price may stabilize at only slightly higher than 91 or 92 cents an ounce.

SILVER IN ELECTRONICS

Electronic industry is one of the principal users of the 100 million ounces of silver consumed annually in the U.S.

Silver Users Association estimates (based on a survey of California users) that some eight million ounces are used for printed circuits, silver cells batteries, waveguide plating and other electronic uses, except soldering, contacts and ceramics.

In the entire electrical industry, soldering and brazing consumes 24 to 27 million ounces, electrical contacts use 18 to 20 million ounces and ceramics take 1 to 13. million ounces

Electronic System Controls Freight Yard

One of nine control towers in computer-controlled freight yard of Canadian National Railways at Montreal. Three miles long and 3,100 feet wide, yard has a capacity of 11,000 cars, can classify 7,000 cars a day. Closed circuit tv is used to read off car numbers. Radar measures car speed during humping for train make-up. Car speed for optimum coupling is worked out by computer and braking is applied to cars automatically in a special track section

TEST, MAINTAIN MICROWAVE SYSTEMS?

Do a more complete, better job faster and more economically with Dymec Microwave Test Sets—Signal Generators

DY-624C X-Band Test Set (above)
DY-5381 High Power X-Band Signal Generator (left)

Dymec Microwave Test Sets and Signal Generators combine several basic instruments in one compact unit to give faster and more economical test and maintenance service for microwave systems.

Each test set includes signal generator, power meter, wavemeter and precision attenuator. They combine to meet a wide range of requirements:

DY-623B SHF Test Set, ideal for use with communications, control and video microwave systems; measures receiver sensitivity and selectivity, plus transmitter frequency and power level.

DY-624C X-Band Test Set, particularly useful for testing complete radar and fire control systems or radar beacon equipment.

DY-5003 X-Band Test Set, incorporates features of the DY-624C, has higher output power, more accurate attenuator, is protected against accidental application of high input signals.

DY-5381 High Power X-Band Signal Generator, provides minimum output of 250 milliwatts over its entire range, approximately 400 mw at band center; especially useful for testing radar systems through directional couplers. Also useful as parametric pump.

DY-5636 H-Band Test Set, covers the important microwave relay communications band, is particularly convenient for testing complete communications systems.

Brief specifications are presented here. Write your Dymec/Hewlett-Packard representative or contact us directly for complete information.

SPECIFICATIONS	DY-623B	DY-624C	DY-5003	DY-5381	DY-5636
Frequency Range	5925-7725 mc[1]	8500-10,000 mc	8500-10,000 mc	8500-10,000 mc	7125-8400 mc
Frequency Meter Range	5820-7780 mc	8500-10,000 mc	8500-10,000 mc	—	7125-8400 mc
Output Power	0 dbm (1 mw)	0 dbm (1 mw)	15 dbm (30 mw)	24 dbm (250 mw)	15 dbm (30 mw)
Output Attenuator Range	70 db	100 db	100 db	100 db	100 db
Internal Modulation	FM, 1 kc	Pulse, 35-3500 cps FM, power line frequency	Pulse, 35-3500 cps FM, power line frequency	Pulse, Square Wave, 35-3500 cps. FM, power line freq.	FM, 1 kc
External Modulation	FM, Pulse, Square Wave, 30 cps to 100 kc	FM, Pulse, Square Wave, 35-3500 cps	Pulse, FM, Square Wave, 35-3500 cps	Pulse, FM, Square Wave, 35-3500 cps	FM, Pulse, Square Wave, 30 cps to 100 kc
Power Measurement Range, CW	— 6 to + 3 dbm	— 6 to + 3 dbm	— 6 to + 3 dbm	—	— 6 to + 3 dbm
Price	$1,900.00 (transit case)	$2,265.00 (cabinet) $2,250.00 (rack mtd.)	$3,600.00 (rack mounted)	$4,835.00 (rack mounted)	$4,475.00 (transit case)

[1] 3 Klystrons needed for full range.

Data subject to change without notice. Prices f.o.b. Palo Alto.

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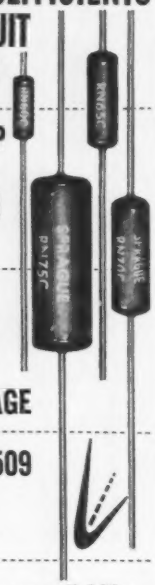

Providing close accuracy, reliability and stability with low controlled temperature coefficients, these molded case metal-film resistors outperform precision wirewound and carbon film resistors. Prime characteristics include minimum inherent noise level, negligible voltage coefficient of resistance and excellent long-time stability under rated load as well as under severe conditions of humidity.

Close tracking of resistance values of 2 or more resistors over a wide temperature range is another key performance characteristic of molded-case Filmistor Metal Film Resistors. This is especially important where they are used to make highly accurate ratio dividers.

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For application engineering assistance, write: Resistor Div., Sprague Electric Co. Nashua, New Hampshire

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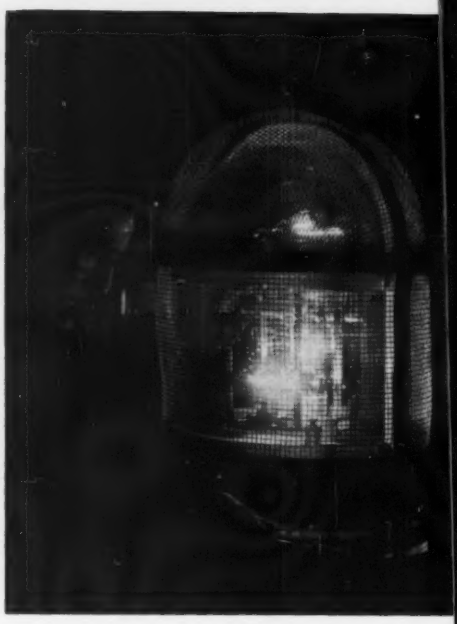
Thin-Film Tunnel Devices Are Still in Research Stage

By MICHAEL F. WOLFF,
Senior Associate Editor



ADL researcher uses vacuum evaporator to fabricate thin-film devices

HOW FAR have researchers gone in applying to practical devices the discovery of quantum-mechanical tunneling in supercooled thin-film devices?

A check made during the past few weeks finds the emphasis still on study of the tunneling phenomenon in prototype devices rather than on attempts to fabricate actual circuit elements.

When this type of tunneling was announced last year (ELECTRONICS, p 11, Nov. 25, 1960), there was considerable speculation on applications in cryogenic electronics. Researchers pointed out potential uses like computer switching and memory circuits, oscillators, triodes, resistors and capacitors.

A General Electric researcher points out that the thinness of the insulating film (about 20 angstroms) makes it difficult to control current. Current has been reproduced in the laboratory to within a factor of two. GE is experimenting with device prototypes and trying to further understand the electron tunneling before concentrating on current control.

Researchers at Arthur D. Little, Inc. explain that utilization of their tunneltron (ELECTRONICS, p 42, Dec. 9, 1960) depends to a great extent on thin-film technology. Their device uses aluminum oxide or barium stearate films whose thickness is limited to the range between roughly 15 and 25 angstroms over an area of 0.1 sq mm.

They are still optimistic about the basic device, however, pointing out that its inherent noise temperature of a few degrees Kelvin and the ability to control the characteristic with a magnetic field make it potentially attractive for cryogenic computers.

Present plans at ADL are to see whether the tunneltron can be used in a practical circuit and also to use the tunneling effect as a tool for further study of superconductivity —as in measuring the width of the energy gap in superconducting metals.

Tunneltron oscillations have been measured in the r-f region. Further circuit studies will aim at making the device oscillate at a frequency predicted from a prior circuit analysis and then seeing how the oscillation parameters are affected by varying bias, temperature and magnetic field. Next step will be to test the tunneltron as an amplifier or rectifier.

Bell Labs is evaluating the potentialities of superconducting thin films for military and other applications, but they too are basically concerned with understanding properties of the materials rather than manufacturing devices.

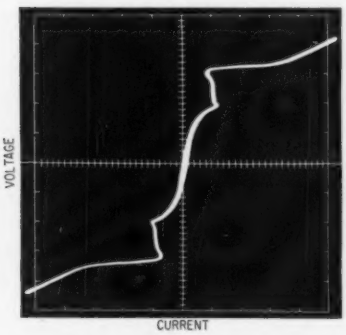
A thin-film device of possibly more general utility is Philco's metal interface amplifier (ELECTRONICS, p 11, June 2, and p 89, Sept. 29, 1961). Consisting of a germanium substrate upon which

successive layers of aluminum, aluminum oxide and gold are deposited, this three-terminal device exhibits at room temperature amplification resembling that of an *NPN* transistor.

Interest remains strong in this device but there is disagreement as to the basic mechanism of operation. Philco researchers attribute the source of energetic electrons to tunnel emission through the thin insulating film. However, R. N. Hall questioned this, at GE Research Lab. He claims that when the aluminum film is evaporated on the germanium substrate, pin holes are formed through which the gold penetrates. Space-charge limited current flows from the gold into the space-charge region at the surface of the germanium and these electrons are collected by the *n*-type germanium as in a depletion-layer transistor.

Experiments at Raytheon discussed at NEREM by J. M. Lavine tend to support Hall's ideas. Lavine felt the majority of electrons collected by the germanium are coming through the pin holes, although a minority may well be energetic tunneling electrons. In the Raytheon research device, power gain of 20 db has been obtained at 1 Kc at room temperature. Beta as large as 200 has been exhibited.

Regardless of the mechanism, the metal interface amplifier is seen as eventually promising active thin-film devices. According to a Philco spokesman, a program of fabrication, testing and analysis has led to a new MIA configuration, including advances in fabrication techniques.



Tunneltron characteristic for lead-tin device at 3.3 degrees K. Vertical scale is 0.5 mv/large div, horizontal is 50 μa/large div

(Advertistment)

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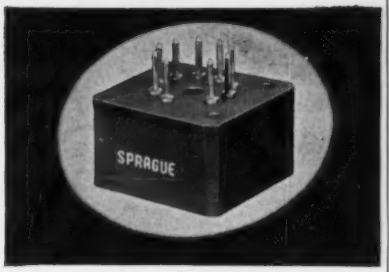

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For further information, or for application engineering assistance without obligation, write to Special Products Division, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

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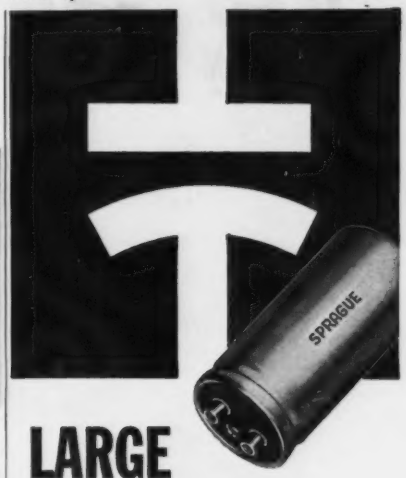

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MEETINGS AHEAD

RELIABILITY AND QUALITY CONTROL, 8th National Symposium, PGRQC of IRE, AIEE, ASQC, EIA; Statler Hilton Hotel, Washington, D. C., **Jan. 9-11, 1962.**

OPTICAL CHARACTER RECOGNITION Symposium, National Bureau of Standards; Department of the Interior Aud., Washington, D.C., **Jan. 15-17, 1962.**

ELECTRICAL ENGINEERING Exposition for electrical-electronics industry, AIEE, New York Coliseum, N.Y.C., **Jan. 29-Feb. 2, 1962.**

REDUNDANCY TECHNIQUES FOR COMPUTING SYSTEMS, Information Systems Branch of Office of Naval Research; Department of Interior Aud., Washington, D. C., **Feb. 6-7, 1962.**

MISSILES & ROCKET TESTING Symposium, Armed Forces Communications and Electronics Association; Cocoa Beach, Fla., **Feb. 6-8, 1962.**

MILITARY ELECTRONICS, 3rd Winter Convention PGMIL of IRE (L.A. Section); Ambassador Hotel, Los Angeles, Calif., **Feb. 7-9, 1962.**

SOLID STATE CIRCUITS, International Conference, PGCT of IRE, AIEE; Sheraton Hotel and U. of Penn., Philadelphia, Pa., **Feb. 14-16, 1962.**

APPLICATION OF SWITCHING THEORY TO SPACE TECHNOLOGY Symposium, USAF, Lockheed Missiles and Space; at Lockheed, Sunnyvale, California, **Feb. 27-Mar. 1962.**

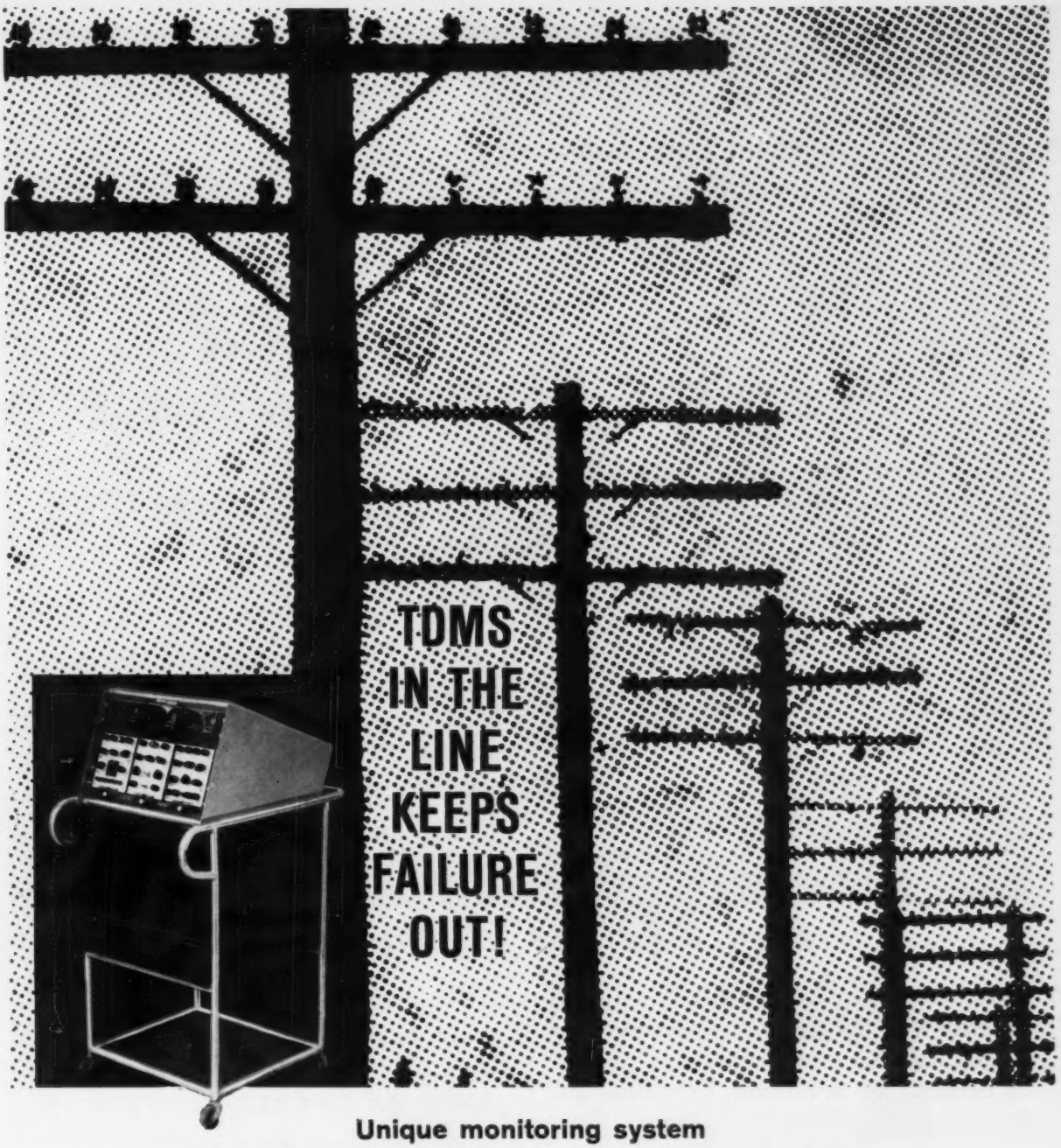
IRE INTERNATIONAL CONVENTION; Coliseum & Waldorf Astoria Hotel, New York City, **Mar. 26-29, 1962.**

SOUTHWEST IRE CONFERENCE AND SHOW; Rice Hotel, Houston, Texas, **April 11-13, 1962.**

JOINT COMPUTER CONFERENCE, PGEC of IRE, AIEE, ACM; Fairmount Hotel, San Francisco, Calif., **May 1-3, 1962.**

ADVANCE REPORT

INTERNATIONAL CONGRESS ON HUMAN FACTORS, *IRE Professional Group on Human Factors in Electronics: Lafayette Hotel, Long Beach, California, May 3-4, 1962. The program will be representative of the scope of the PGHFE as an interdisciplinary group of engineers and scientists. Papers that clearly deal with problems of human factors are solicited in the following areas: automatic control, biological science, communications, computers, cybernetics, electrical engineering information theory, mathematics, medicine, and psychology. Submitted papers should present new research findings, either experimental or theoretical with the experimental implications called out. Papers should illustrate the power and necessity of an interdisciplinary approach to the human factors area. Preferably papers should not exceed 30 minutes of presentation length. Abstracts of less than 300 words should be sent before January 1 to John W. Senders, Technical Program Committee Chairman, Minneapolis-Honeywell Regulator Company, 2600 Ridgewood Road, Minn. Final manuscripts of papers tentatively accepted on basis of abstracts should be submitted before February 15.*



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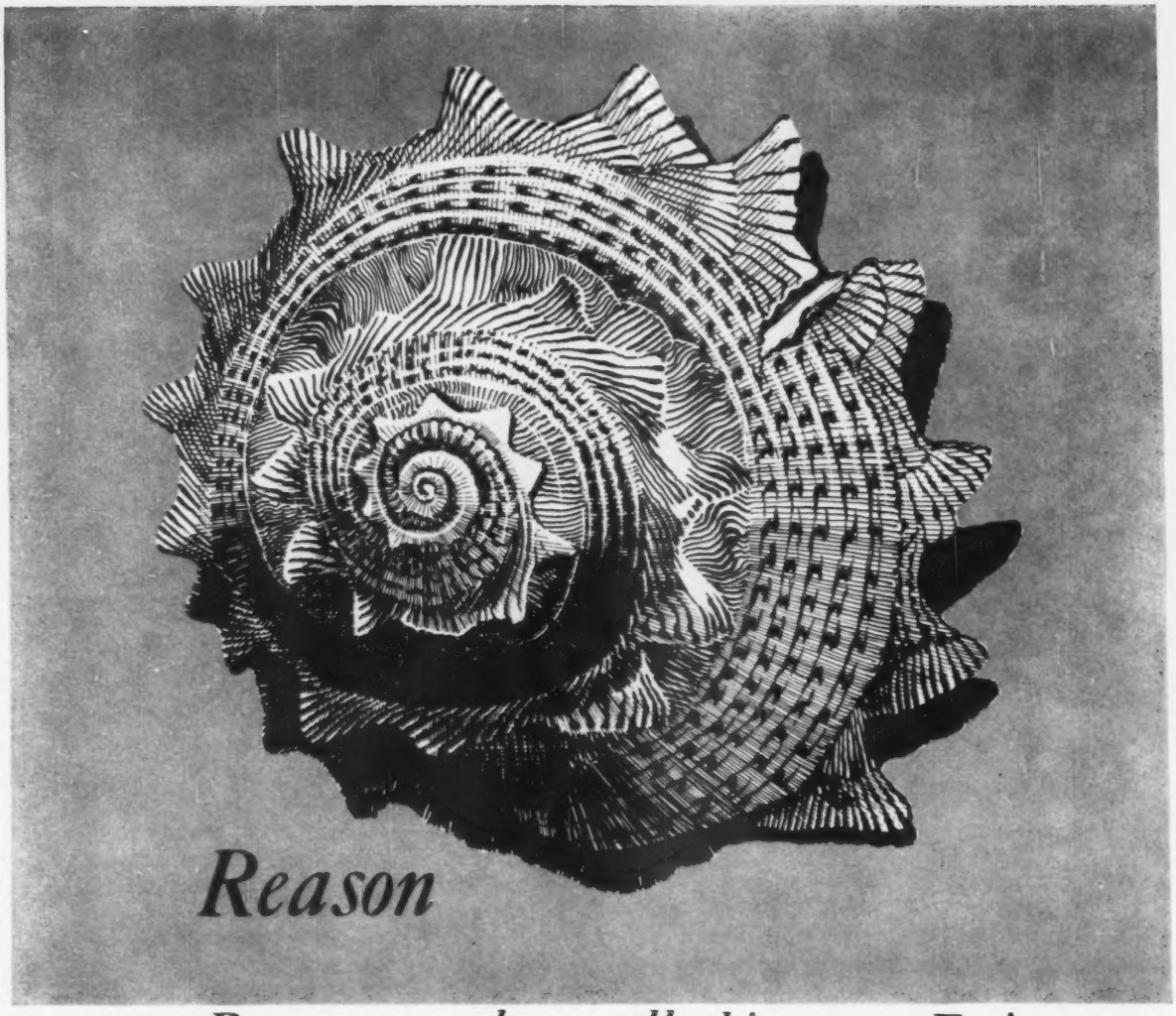

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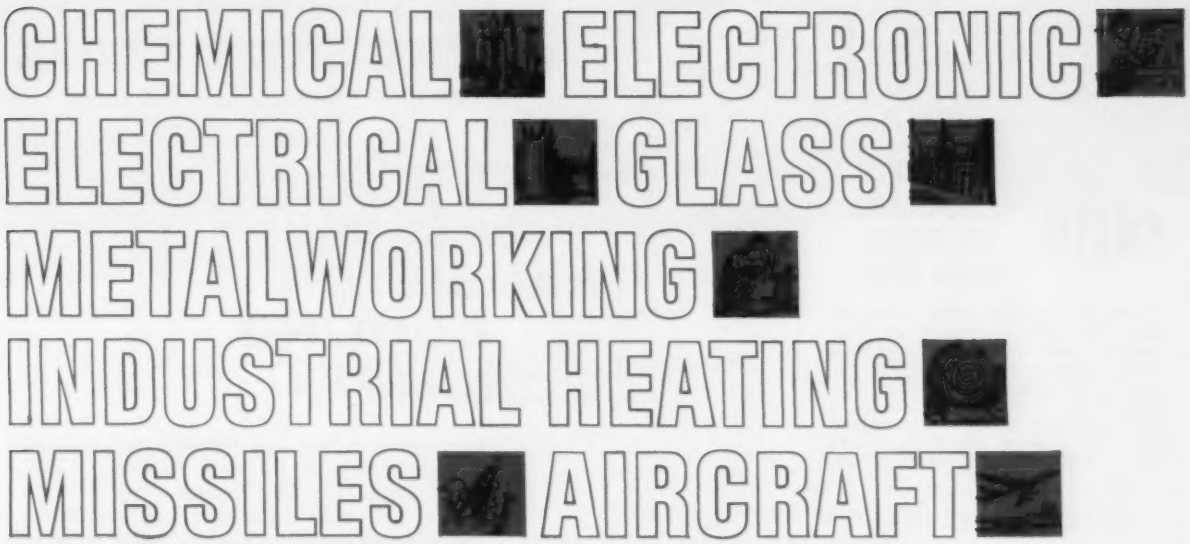

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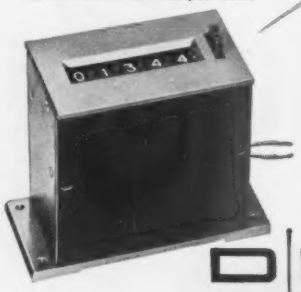

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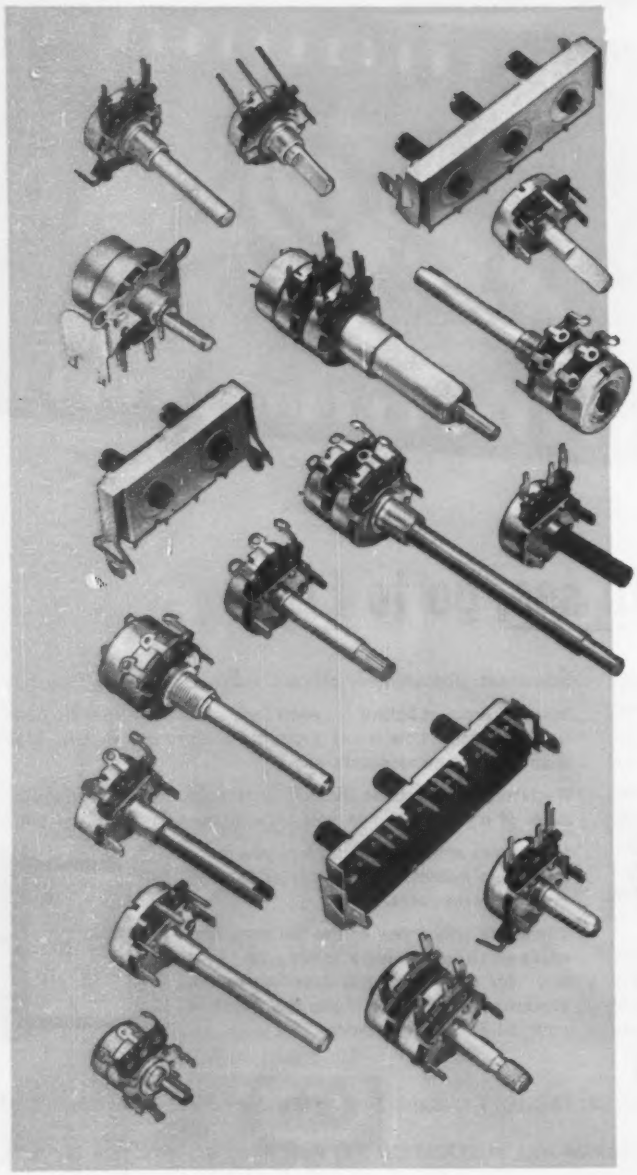

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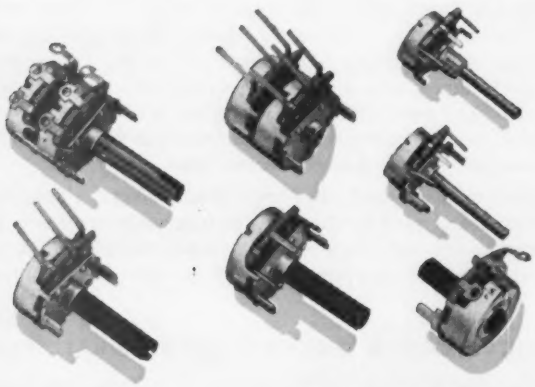

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750 volts, dc. ..... ½ watt, Min. } on value.

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750 volts, dc. ..... ½ watt, Min. } on value.

SHELF LIFE ..... Unlimited

NOISE ..... 3 to 8 millivolts, values below 500,000 ohms.
8 to 12 millivolts, values above 500,000 ohms.

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ZERO LOAD @ 100°C for 1000 hours
±4%, values to 100k; ±2%, values above 100k.

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Less than ±0.01% per volt. (±0.005% per volt, avg.)

TEMPERATURE CHARACTERISTIC
±3% from 20°C to 105°C

HUMIDITY: 95% RH @ 40°C for 240 hours
±4% to ±5%, values to 250k; ±6% to ±9%, values above 250k.

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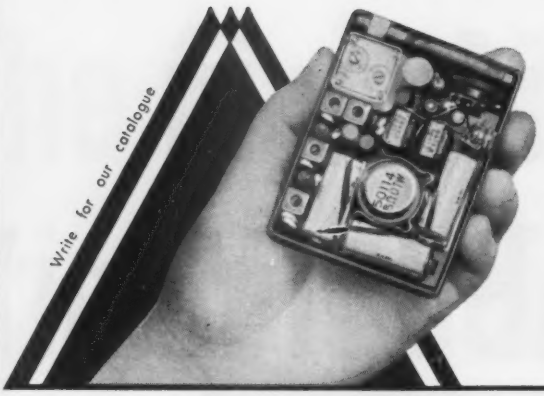

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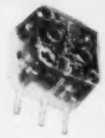
The high standards of MITSUMI electronic components are insured by a fully-automated assembly system, and double-checked by rigid quality controls. Mitsumi Electric Company is Japan's largest manufacturer of components for radio, television and communications equipment.

POLYVARICON Variable Capacitor



MITSUMI PARTS

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Komae, Kitatama, Tokyo

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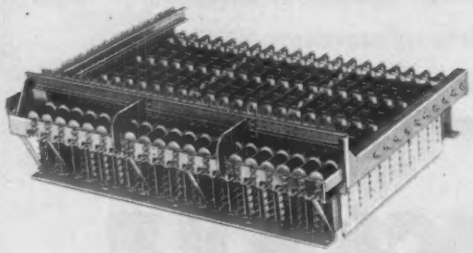
This Random-Access Crossbar Stores 200 6-Bit Instructions for Machine-Tool and Process Control. Access Time <12 Milliseconds.



Minimize electronics, maximize reliability with this unique* coordinately-actuated, high-speed electromechanical matrix — the ideal link between punched tape or cards and machine or process controls. 20 million operations/crosspoint rated, 100 million regularly achieved. Hundreds of modern automated devices are designed around the logic capabilities of Crossbar. Write. We'll tell you how and why.

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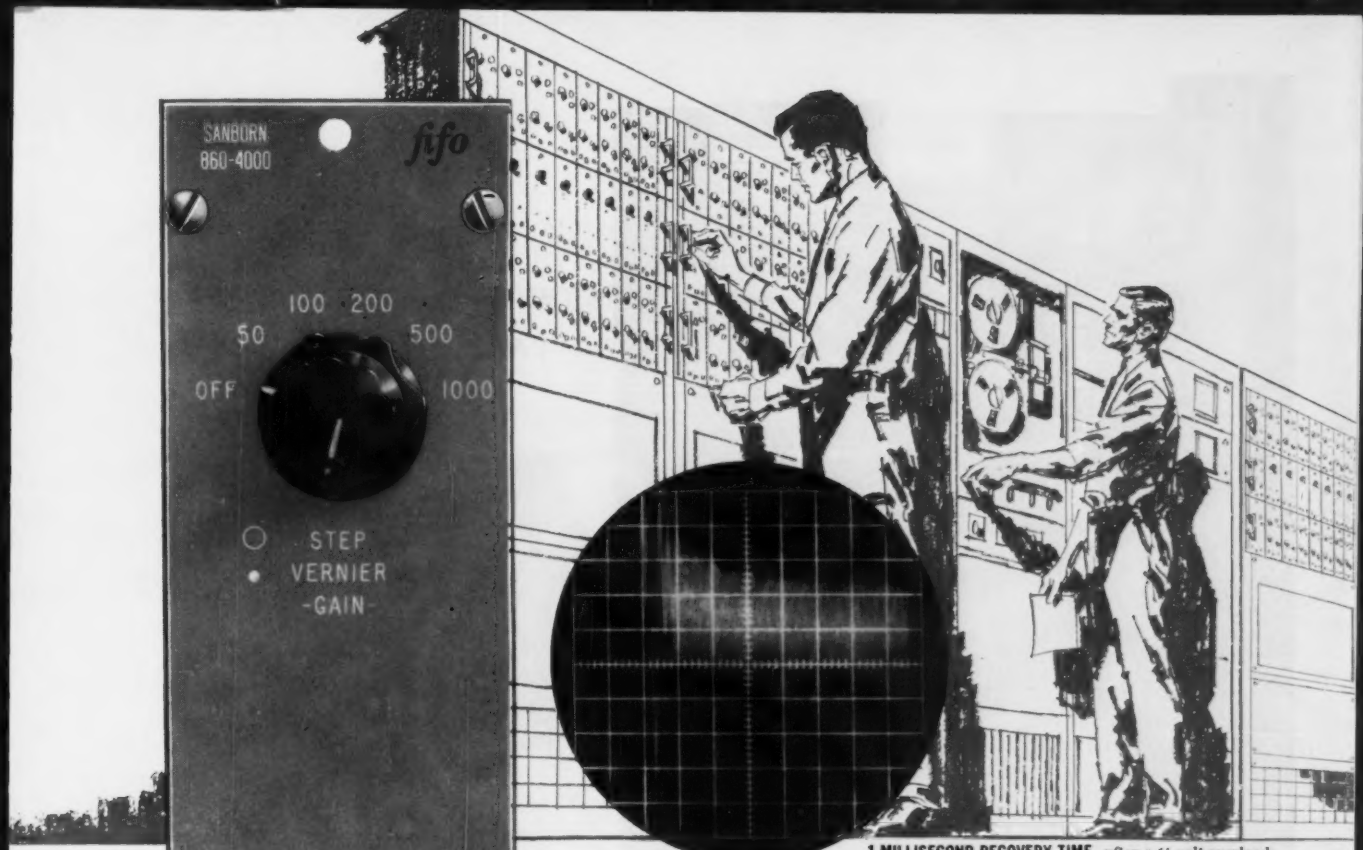
CIRCLE 208 ON READER SERVICE CARD



1 MILLISECOND RECOVERY TIME *after a 1½-volt overload. Time base, 1/2 ms/div; amplitude, 2% of full scale. A small AC signal was mixed with the overload to increase visibility of recovery trace.*

NEW 0-10 KC Floating Input-Floating Output DC AMPLIFIER

Sanborn® FIFO—fully transistorized, shown actual size

The new FIFO (floating input—floating output) is a fully transistorized amplifier designed especially for obtaining data from wide bandwidth transducers. A single FIFO used with an input scanner can amplify data from many transducers, or the outputs of any number of FIFO amplifiers may be sampled.

Model 860-4000, with gain of 1000, is particularly useful for extracting low level signals from a high noise level. Model 860-4000P (with grounded output isolated from input) can deliver ±5 volts at ±100 ma and is suitable for driving high frequency galvanometers. Both FIFO models have a high common mode rejection ratio and, as illustrated by the 'scope photo, exceptional overload recovery capability.

The FIFO amplifier is available in a portable case with individual power supply. Two channels with individual power supplies are available on a 3½" x 19" panel for rack mounting, or you can mount eight amplifiers in 7" x 19" with a Sanborn Model 868-500F 8-channel power supply.

Contact the Sanborn Industrial Sales-Engineering representative nearest you or write the main office in Waltham for complete information and engineering assistance.

SPECIFICATIONS: MODEL 860-4000 FIFO AMPLIFIER

Isolated, floating, guarded input – 100 meg. impedance min. at DC

Isolated, floating output – impedance less than 35 ohms

Bandwidth DC to 3 db down at 10 KC

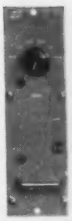
Max. Gain of 1000—10 mv in gives ±10 volts out across 1000 ohms (floating). Optional Model 860-4000P with power output isolated from input can deliver ±5 volts at ±100 ma at ground potential

Linearity ±0.1% of 10-volt floating output at DC

High Common Mode Rejection—160 db at DC, 120 db at 60 cps, 100 db at 400 cps, with 1000 ohms unbalance at source

Drift 2 uv, Noise 7 uv RMS

Specifications subject to change without notice.



For DC to 100 cps bandwidth

DATA PREAMPLIFIER 860-1500S

Has floating, guarded input and floating output; delivers ±5 volts across 2000 ohms; linearity ±0.05% of full scale (5 volts); bandwidth DC to 3 db down at 100 cps; rejection ratio 10^6:1 with 5000-ohm source unbalance at 60 cycles. Either fixed gain between 10 and 2000, or with attenuator to provide any selected gain within this range. Amplifier has less than 2 uv drift and less than 3 uv peak-to-peak noise.

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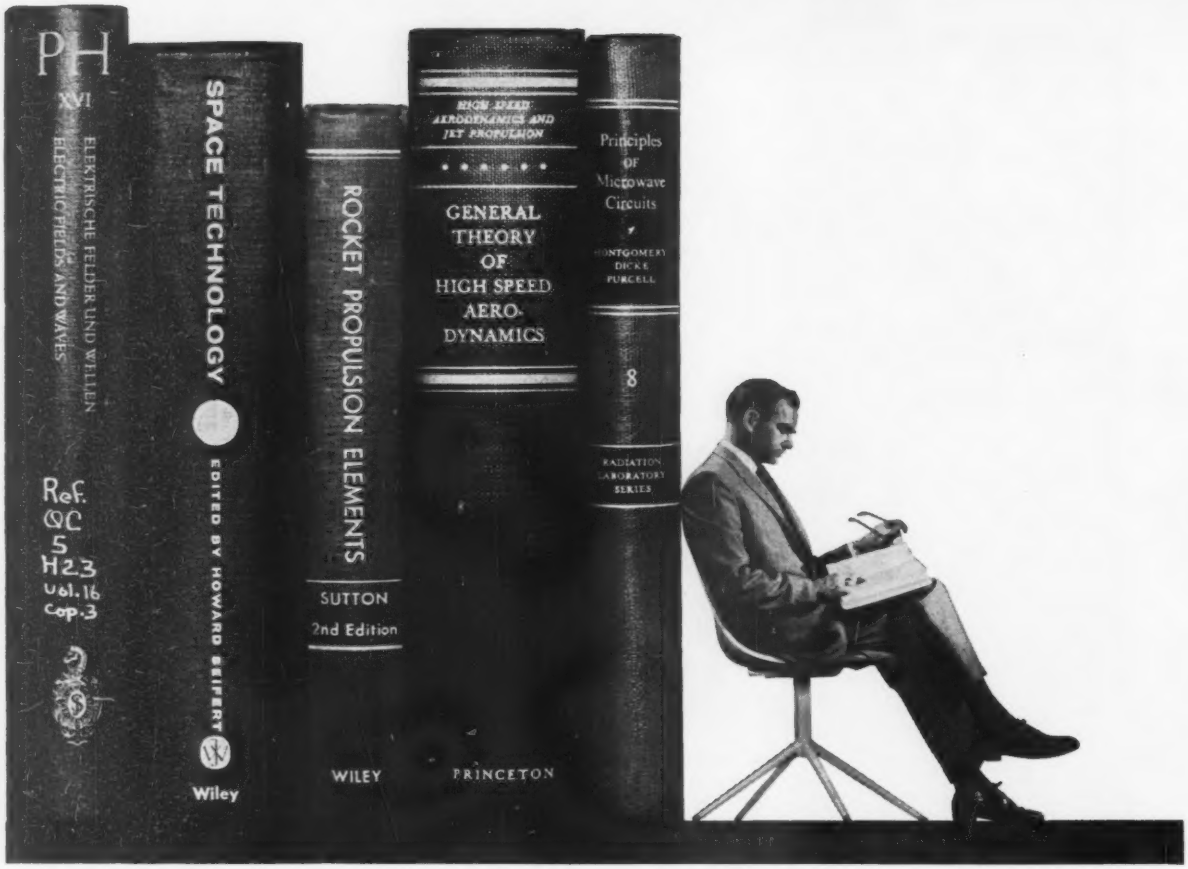

scientists and engineers in a unique role

The frontiers of space science and technology are being expanded at Aerospace Corporation. The scientists and engineers of this organization are the critical civilian link uniting government and the scientific-industrial team developing space systems and advanced ballistic missiles. In this mission Aerospace Corporation provides advanced systems analysis and planning, theoretical and experimental research, initial systems engineering, initial technical direction and general technical supervision. Included in the latter are integration and review of the engineering, development and test operations of industry to the extent necessary to assure achievement of system concept and objectives in an economical and timely manner. These people are privileged to view both the state-of-the-art and system development in their totality. Immediate assignments exist for those individuals highly skilled in these specialties and who are knowledgeable in inter-disciplinary problem solving. Men with advanced degrees are urged to contact Aerospace Corporation, Room 110, P.O. Box 95081, Los Angeles 45, California.

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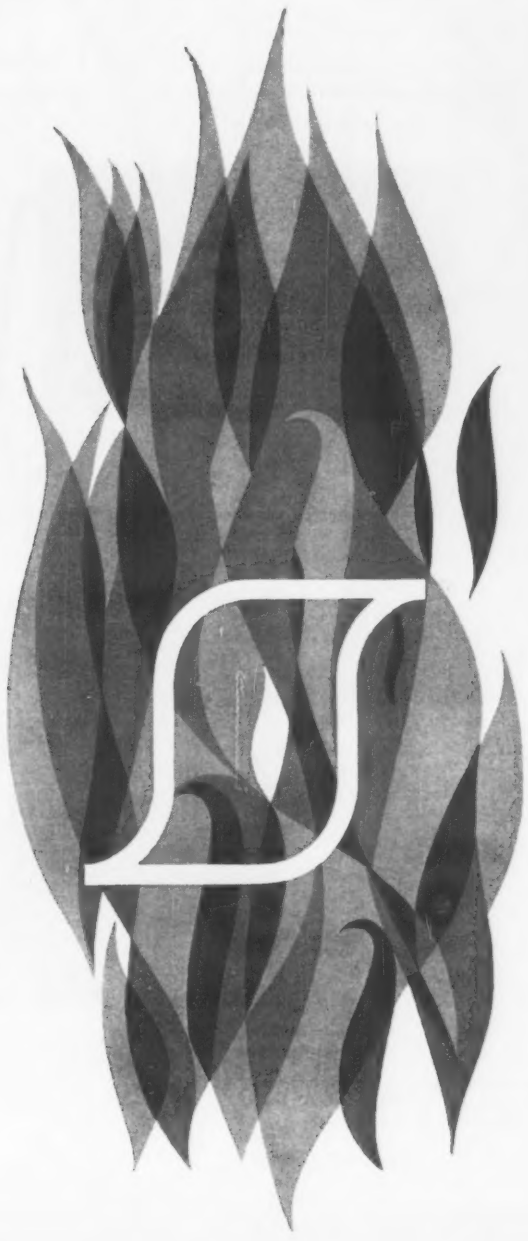
NEW TAPES TAME DESTRUCTIVE HEAD-HEAT COMPLEX

SCOTCH® BRAND *Heavy Duty Instrumentation Tapes take new speed and friction tensions in stride!*



Today's trend to speed-up in the recording of instrumentation data—with tape speeds up to 120 inches per second—can mean "*Slow Down, Trouble Ahead!*" for tapes that can't cope. On the other hand, "SCOTCH" BRAND Heavy Duty Tapes love to live dangerously—are made for challenging environments where tape speeds are fast and getting faster, where instantaneous temperatures caused by friction between tape and head shoot up. Two new "SCOTCH" Tapes—Heavy Duty Tapes 498 and 499—are especially designed for applications where ordinary tapes soon wear out.

They live 15 lives. Actual field tests show that "SCOTCH" BRAND Heavy Duty Tapes last 15 times as long as standard tapes . . . stoutly resist high temperatures, both externally and internally generated. In instrumentation uses, where tensions caused by friction and heat make tape wear an important factor, these Heavy Duty Tapes preserve the integrity of the coating, minimize rub-off and particle redistribution that separate tape from head . . . and *you* from a signal.

When the heat's on for ordinary tape (above 150°F.), the binder softens and coating loosens from backing. Then the dropout count mounts. Not so with "SCOTCH" Heavy Duty Tapes! They cooly withstand the damaging effects of temperatures up to 250°F., without blocking or layer-to-layer adhesion. And excellent resolution is maintained at high and low frequencies.

High conductivity is another feature of "SCOTCH" Heavy Duty Tapes . . . nearly 1000 times that of conventional tapes! Static charges drain off without building up . . . you get a smooth, clean tape pass every time, with excellent resolution. This efficient static drain-off makes stray contaminants less likely to be attracted to the tape.

At tape-killing paces—in speeds, tensions, temperatures—we suggest you consider these heavy-duty champions of the tape world: No. 498 and (for extra recording time) No. 499. And for all your needs—in data acquisition, reduction, or control—there is a right "SCOTCH" BRAND tape for the job.

Call your 3M Representative in all major cities . . . he's a helpful guy, a convenient source of supply and information. Consult him for details or write: Magnetic Products Div., 3M Co., St. Paul, Minn.

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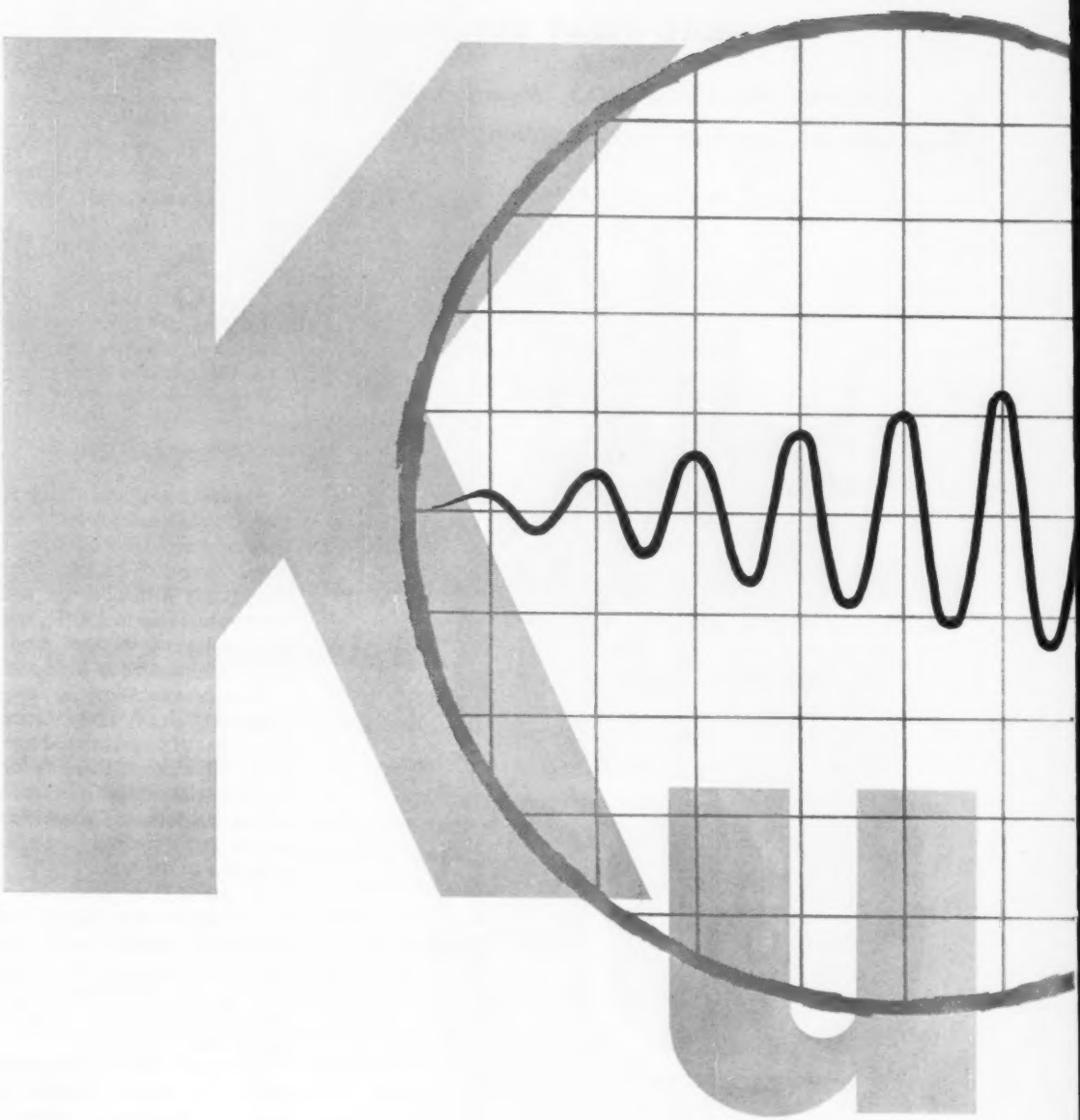
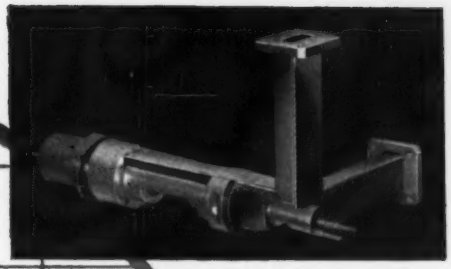
Magnetic Products Division 3M COMPANY

ELECTRONICS
PROGRESS IN MICROWAVE TECHNOLOGY



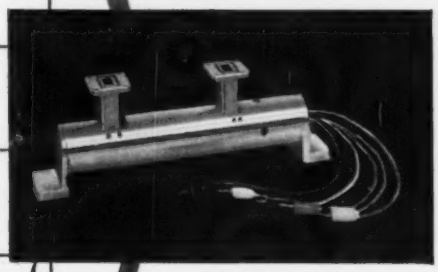
1 Kw
14-18 Kmc

General Electric Announces Three K_u Band TWT's With Power Up to 1 Kw



Z-5183 (CW)
(without solenoid)

Saturation Gain.....30 decibels, min
Power Output, CW...10 w, nominal
Length.....9 inches
Weight (including solenoid) 34 pounds



Z-5182 (CW)
(PPM)

Saturation Gain.....30 decibels, min
Power Output, CW...150 mw, min
Length.....11.2 inches
Weight.....3.0 pounds

Z-5184 (Pulsed)
(without solenoid)

Saturation Gain.....25 decibels, min
Power Output, peak..1 kw, nominal
Duty Cycle.....0.01, nominal
Length.....11 inches
Weight (including solenoid) 20 pounds

A significant breakthrough in microwave technology now permits General Electric to offer highest available K_u Band power output.

Developed under an Air Force contract, the three new tubes can be operated singly or in cascade. The highest rated TWT, Z-5184, delivers 1 kw peak. The Z-5183 delivers 10 w CW, and the Z-5182, 150 mw CW.

With their broad bandwidth, high gain, and rugged metal-ceramic construction, General Electric TWT's offer optimum performance in critical applications, such as radar, CW amplification, ECM, microwave relay systems and radiometry. They are also particularly suitable for aircraft and space vehicle systems.

Sample tubes are available for customer evaluation. To obtain more information on these General Electric traveling-wave tubes, contact your nearest Power Tube Sales Office (telephone numbers listed below). Or write to Power Tube Department, G-E Company, Schenectady, N. Y., for bulletin PT-58.

265-12-9545-8481-44

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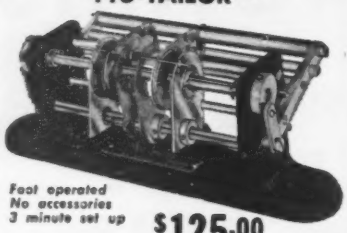

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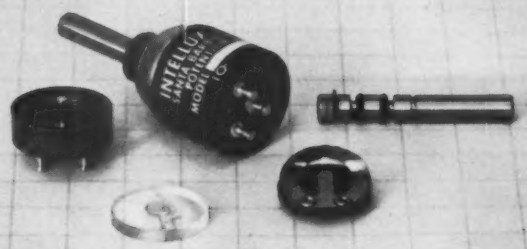

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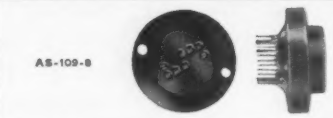

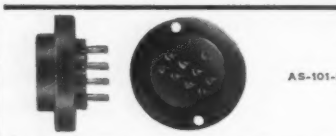

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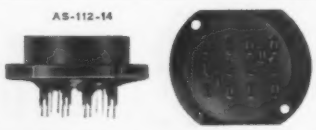

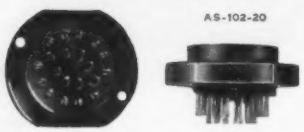

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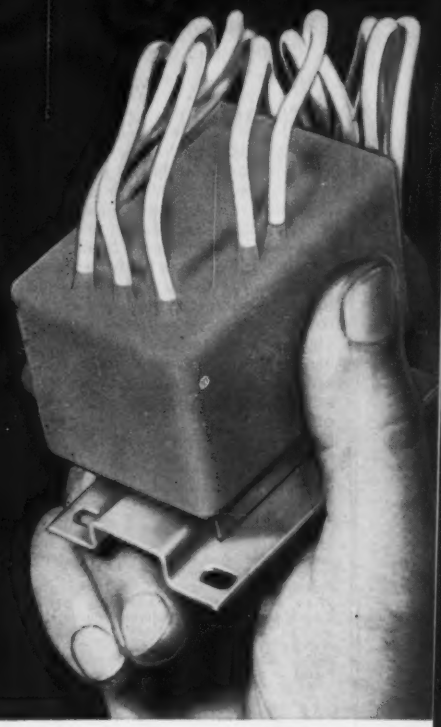
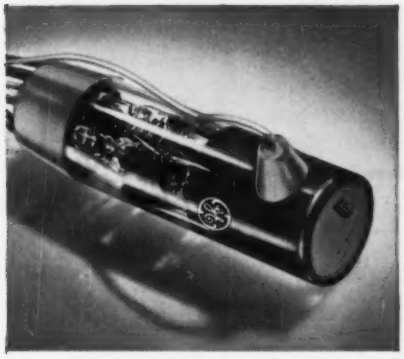
An equal opportunity employer

Different potting and encapsulating problems require different solutions. That's why General Electric offers a family of eight RTV and LTV silicones. LTV-602, for instance, is transparent, resilient and very easy to repair, curing in two hours. RTV liquid silicone rubber compounds offer good physical strength, resiliency and a selection of viscosities for impregnation, potting, conformal coatings or sealing.



8 fast cures for potting and encapsulating problems

General Electric Silicones protect against temperature, moisture, ozone, thermal and mechanical shock



Why are G-E silicones used? To protect against temperature extremes from −65°F to 600°F . . . to provide a resilient, shock-absorbing cushion for delicate parts . . . for outstanding electrical properties . . . for their very low (0.2%) shrinkage . . . for their resistance to moisture, ozone and thermal shock.

How are G-E silicones used? By dipping, pouring, spraying or buttering. Cure times can be varied from minutes to hours, depending on catalyst used and the heat applied (from room temperature to 125°C). They bond easily to properly primed surfaces, are easily removed from unprimed surfaces.

	COLOR	VISCOSITY POISES	CONSISTENCY
LTV-602	Clear	15	Easily Pourable
RTV-11	White	120	
RTV-20	Pink	300	Pourable
RTV-40	White	450	
RTV-60	Red	550	
RTV-77	White	8,000	Spreadable Thixotropic Paste
RTV-88	Red	10,000	
RTV-90	Red	12,000	Stiff Paste

Which is best for you? G-E encapsulants vary in viscosity from a readily pourable liquid to a thick paste to fit special requirements. Applications range from deep impregnation of transformer coils to caulking of large equipment . . . from printed circuit encapsulation to making flexible molds.

Write for complete data. If you would like a free sample for evaluation, write on your business letterhead describing your proposed application. Section N1264, Silicone Products Dept., General Electric Co., Waterford, New York.

GENERAL ELECTRIC

CIRCLE 49 ON READER SERVICE CARD

WILLIAM C. DIMAN,
Hayes Furnace Division Manager, explains . . .

WHY ELECTRONICS TURN TO HAYES

Extremely Close Process Control is vital in manufacturing semi-conductors and other electronic parts. Without this control, costs and scrap rates go up, product performance becomes unpredictable, and product life is drastically reduced. *The Trend Is To Hayes*—More and more electronic firms are looking to Hayes for consulting assistance and for equipment to solve complex and exacting heat treat jobs. Here are some "for instances" of the advanced equipment Hayes is offering:

HAYES BA-19D DIFFUSION FURNACE Highly precise unit assures even diffusion on silicon or germanium wafers. Extremely critical temp. control (reactor type). Uniform "flat" zone in depositing chamber totally free from temp. "ripples". Engineered atmospheres and distribution. Built-in program controller and instrument panel. Silicon carbide heating elements — temps. to 1350°C. Easy to maintain. Shipped complete, ready to operate. Type LA-19D furnace with nickel-chrome elements — temps. to 1000°C.

HAYES LAC-55M ALLOYING FURNACE Now used by many major electronics firms for alloying, metal bonding, soldering, other applications requiring close temp. control through 300°C to 1100°C. Unusual flexibility. 5-zone temp. control . . . maintain temps. within ±½°C.

HAYES MS-31R RECIRCULATING DRYER Molecu-Dryer complete with gas/air recirculating unit, for "dry box" atmospheres for assembly of transistors diodes, other electronic parts. Dew points to –100°F or lower, Economical — replaces expensive tank nitrogen. Simple controls. Easy maintenance. Standard units caps. to 16,000 CFH. Higher caps. on special order.

Hayes equipment covers every electronics requirement: zone refining, crystal growing, alloying, metal bonding, glass (or ceramic)-to-metal sealing, vacuum heat treating, high temp. outgassing, air/gas drying, atmosphere generation (hydrogen, nitrogen, dissociated ammonia, forming gas, endo and exo gases.) With theoretical development work in the lab backed-up by a double-check on actual production-scale equipment . . . Hayes can help you improve quality, cut costs, increase production. Write for Bulletin 5711C.

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Hogan specializes in electrolytic techniques for event, spectrum analysis, oscillograph and facsimile recording, frequency time analysis and special purpose binary and gray scale record applications. Hogan electrolytic recording papers provide a permanent high contrast black on white record which is reproducible on most conventional office duplicators.

Whatever your recording problem may be — contact *HOGAN FAXimile, a subsidiary of TELautograph Corporation, 635 Greenwich Street, New York 14, N. Y.*

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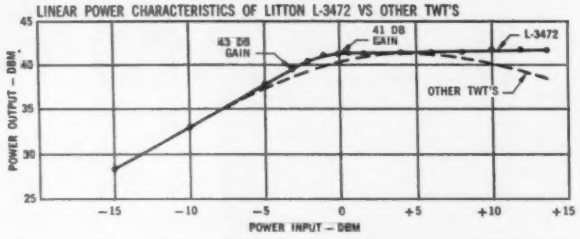

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L-3663	2000-4000	10 W	33 db	CW
L-3619	2000-4000	20 W	33 db	CW
L-3470	4000-8000	20 mW	36 db	CW
L-3711	4000-8000	1 W	36 db	CW
L-3471	4000-8000	2 W	36 db	CW
L-3657	4000-8000	10 W	33 db	CW
L-3658	4000-8000	20 W	33 db	CW
L-3611	7000-11000	20 mW	36 db	CW
L-3612	7000-11000	2 W	36 db	CW
L-3528	5000-11000	5 W	33 db	CW
L-3472	7000-11000	10 W	36 db	CW
L-3529	7000-11000	20 W	36 db	CW
L-3614	8000-11000	1 kW	36 db	.02
L-3497*	1240-1400	5.5 kW	40 db	.06
L-3674*	400- 450	5 kW	37 db	.06
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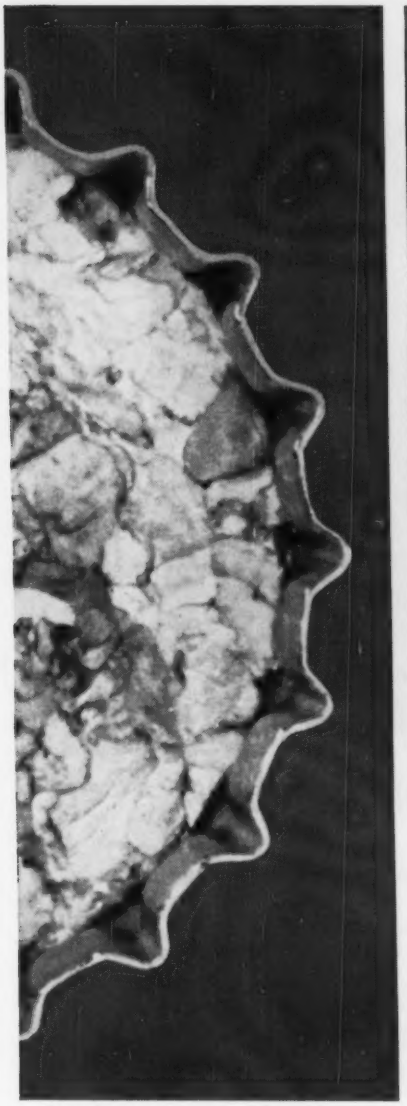

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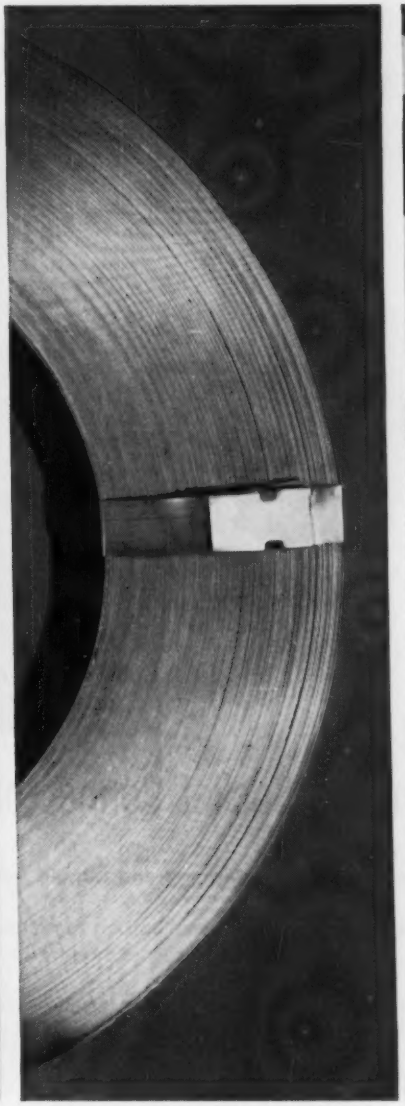

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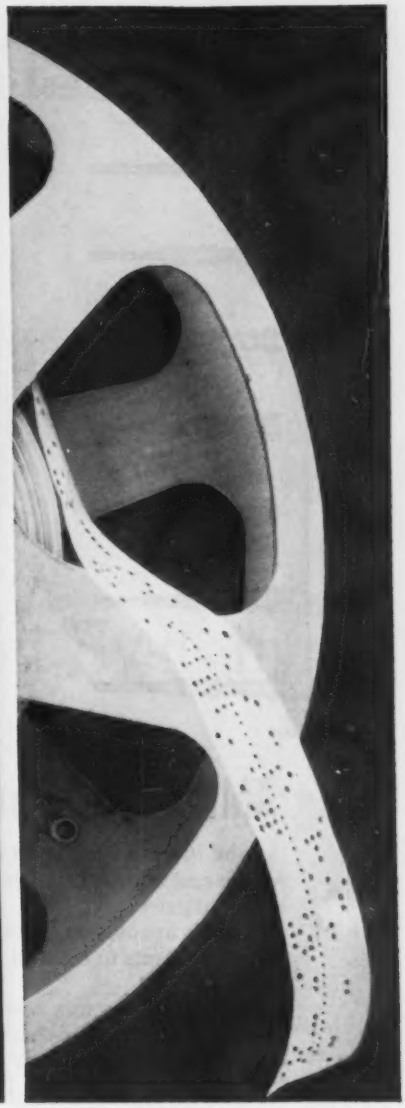

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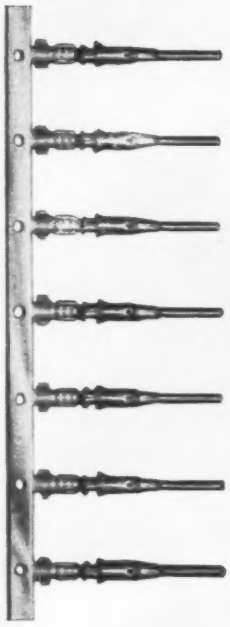

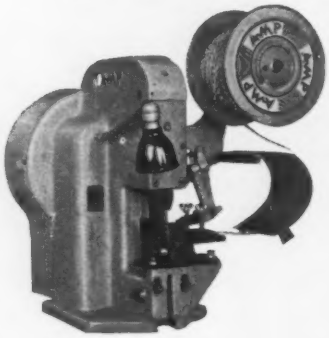

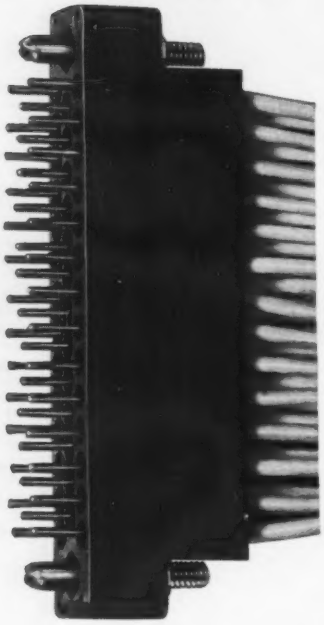

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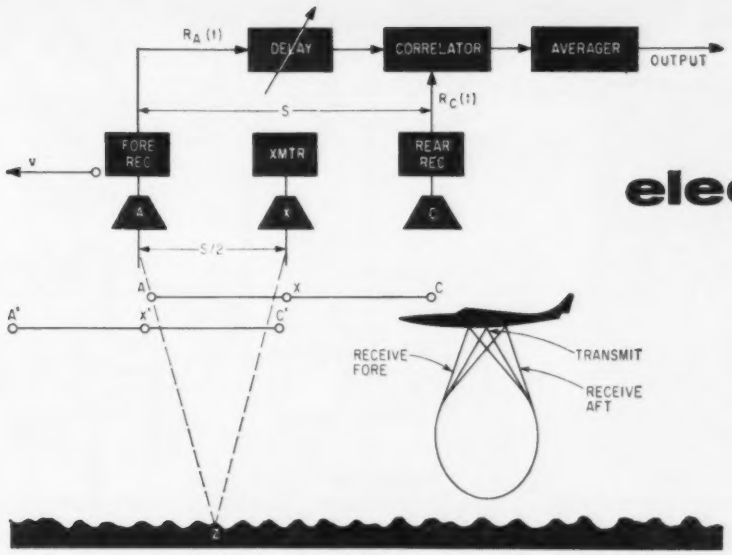


FIG. 1—Basic navigation system using correlation techniques. Inset of aircraft to right shows the transmit and receiver beam configuration

Air and Space Navigation System

USES CROSS-CORRELATION DETECTION TECHNIQUES

By RAYMOND J. MILLER, Advanced Guidance and Navigation Unit, Light Military Electronics Dept., Advanced Electronics Center, General Electric Co., Ithaca, N. Y.

Time-domain measurement of reflected microwave beams determines surface velocity of aircraft or space vehicles. Time measurement is made by correlating echo signals received by several separated antennas

THE CORRELATION NAVIGATOR is a self-contained surface speed and drift angle measuring system with capabilities for measuring altitude above terrain and vertical velocity.

This navigator is independent of the nature of the terrain and sea states encountered during operation. Unlike doppler systems, the system takes advantage of unique characteristics of radar signal returns from individual scatterers.

Self-contained velocity sensors using doppler frequency measurements of the echo power from one or more microwave beams have been developed. It is also possible to make a time-domain measurement of reflected microwave beams to determine surface velocity of a moving vehicle (see Ref.). This time measurement is made by correlating the echo signals received by several separated antennas.

The inset in Fig. 1 shows transmit and receive beam configuration. One advantage over a doppler navigator is that a single wide beam of microwave energy is transmitted and the center of this beam is oriented perpendicular to the underlying reflecting surface. Ordinarily this reflecting surface would be the earth; however, the velocity sensing capability would be equally useful during approaches to the moon or other planets. Several receiving antennas are used and these also have vertically oriented broad-beam patterns. Because of the broad r-f beam patterns, small horn antennas are used throughout. This is not done as a technical trade-off: accuracy of the correlation technique is

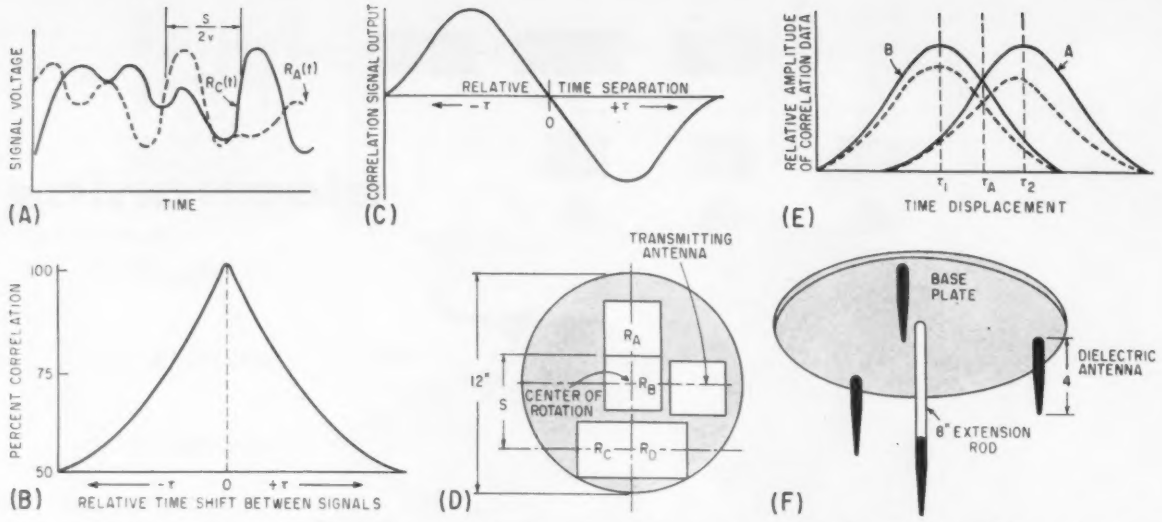


FIG. 2—Typical samples of $R_A(t)$ and $R_C(t)$ (A); autocorrelation curve for random function (B); differentiated correlation curve (C); antenna layout (D); data correlation curves (E); design of a receiving antenna that includes measurement of vertical velocity (F)

enhanced by use of small antennas and broad beamwidths.

The cross-correlation detection technique is based upon the principle that the echo return from a set of fixed scatters at a point in space under identical conditions of transmission and reception is unique and reproducible at different times. This principle has been employed in airborne MTI systems to remove the ground clutter, and is a function of the aircraft velocity. The MTI technique accomplishes clutter removal by electrically phase-displacing the center of the receiving antenna so that during a pulse repetition interval, the antenna remains effectively stationary. The correlation navigator reverses this process by seeking out the amount of electrical phase shift required for maximum cancellation and then determining vehicle surface velocity from this information.

Figure 1 shows a simple correlation navigator including the relative positioning of the antennas and the method of signal processing. A single transmitter horn, *X*, and two receiving horns, *A* and *C*, are shown. Directly beneath the horns, two system positions in time are indicated. The two positions are separated by a distance, $S/2$, and in time by τ.

Figure 1 shows that the path followed by transmitted energy to a scatterer, *Z*, and back to the receiving antenna, *A*, is identical to, but reversed in direction from, the path followed by transmitted energy which is reflected τ time later from scatterer *Z* back to receiving antenna *C*.

This example has only a single scatterer. However, the same argument holds for all other scatterers within the surface area intercepted and illuminated by the transmitted beam. Thus, the integrated received signals indicated by $R_A(t)$ and $R_C(t)$ in Fig. 1 are similar, but displaced in time by τ.

From Fig. 1, τ is inversely proportional to the indicated velocity, *V*, and is defined by:

$$\tau = \frac{\text{distance}}{\text{velocity}} = \frac{S/2}{V} = \frac{S}{2V} \text{ or } V = \frac{S}{2\tau} \quad (1)$$

The detected signals, $R_A(t)$ and $R_C(t)$, are band-limited random noise signals, generally limited to the audio spectrum.

The upper frequency limit of the detected signals is directly proportional to the frequency of transmission twice the velocity of the vehicle and the sine of one-half the transmitted beam angle. Fig. 2A shows how typical samples of $R_A(t)$ and $R_C(t)$ would look.

In Eq. 1, *S* is known and can be measured as the mechanical spacing between the two receiving antennas. More properly, *S* is the spacing between the electrical centers of the two receiving antennas, and for high accuracy systems, the exact value of *S* must be ascertained during system operation over a calibrated course. Although *S* is a critical dimension in the measurement of *V*, the main criterion is that *S* remain fixed once the system has been calibrated. Original fabrication errors can be calibrated out of the system and through proper construction techniques, *S* can be held stable over the system operating environmental ranges.

Time τ is a measurable function and is denoted as the time spacing between $R_A(t)$ and $R_C(t)$ in Fig. 2A. As indicated in Fig. 1, $R_A(t)$ is passed through a variable delay line and the delayed $R_A(t)$ is correlated against $R_C(t)$ as the delay time is varied. When maximum correlation is achieved, the corresponding delay time is read out and substituted in Eq. 1 for τ to establish the related value of *V*. This maximum correlation is achieved when the function $R_A(t)$ of Fig. 2A is slid in time to the right until it is superimposed directly on function $R_C(t)$.

The position of the transmitting antenna midway betwen the receiving antennas (Fig. 1), is not essential in an operational system. The transmitting antenna may be at any convenient place on the vehicle, and can be the radar transmitter for another onboard system if it is at the same frequency and illuminates the desired surface area to provide a satisfactory backscattered signal.

Figure 2B shows a typical autocorrelation curve for a random function. The curve is symmetrical about the zero relative time shift

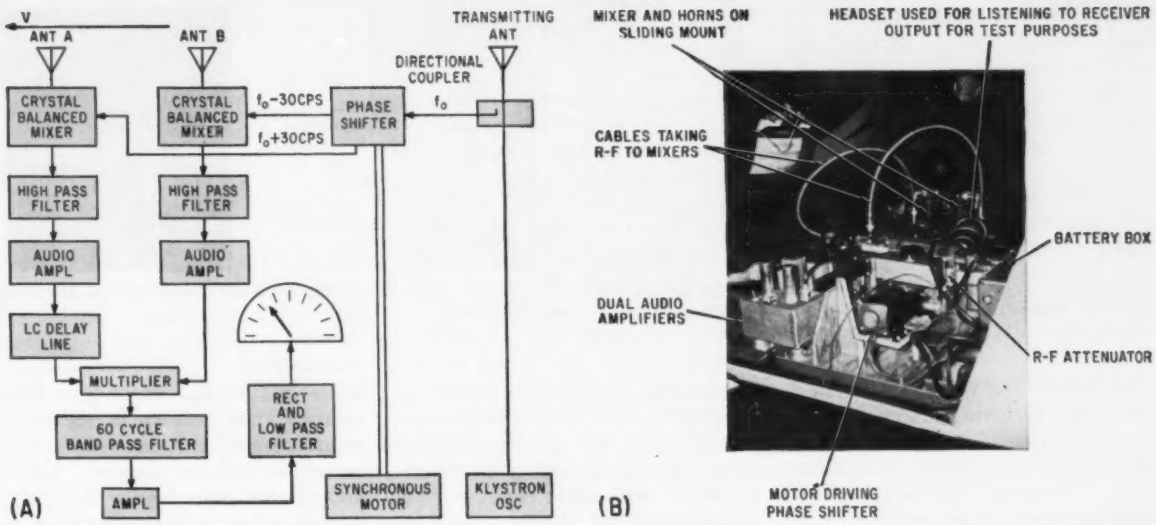


FIG. 3—Experimental correlation navigator radar that was flight tested (A); and navigator shown mounted in the test aircraft (B)

between the two signals. Since τ must be measured accurately to determine V, it is desirable to operate on the correlation curve in a region where a small change in τ results in a significant change in the correlation output signal. Therefore operation at the peak of the correlation curve is undesirable since the curve passes through zero slope in this region. One way to accomplish the desired effect is to differentiate one of the received signals prior to correlation with the other received signal. This is equivalent to differentiating the correlation curve, and results in a curve similar to Fig. 2C. This curve has maximum slope in the desired region of operation near $\tau = 0$.

However, this technique is not desirable: it requires a null detector operating about the zero signal level during lock-on; for operation over a sea surface and due to the decorrelation effects of a moving sea surface, the correlation curve itself becomes distorted so that it is no longer symmetrical and the zero crossover in Fig. 2B shifts. Although unrelated, this would produce a velocity measurement error somewhat equivalent to a sea bias error in a doppler system.

The foregoing discussion leads to the data processing technique used in the correlation navigator. Consider Fig. 2D which shows the actual antenna structure layout.

Four receiving horns and one transmitting horn are used. Actual

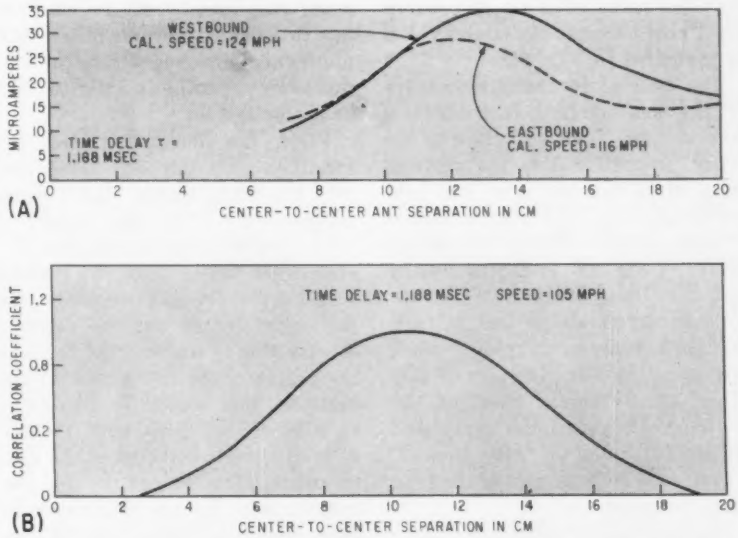


FIG. 4—Flight test data: (A) westbound peak position is 13.2, eastbound 12.3. Calculated speed (mph) = $X/2\tau$ (where X is peak position in cm). Theoretical curve of cross correlation vs antenna separation (B)

antenna type and size will vary somewhat with the specific application, but in general each horn is approximately 3 inches square (assuming X-band transmission), resulting in an integral antenna structure of under 12 inches in diameter. With this antenna arrangement and with appropriate switching, the backscattered and received signals are processed to provide surface speed and drift angle information to a navigation computer.

In obtaining surface speed information, the signal received by each of the forward horns is alternately correlated against the signals received by the rear pair. Since a different physical spacing is associated with these alternate correlations, two time spacings are associated with the two peak correlations (see Fig. 2E).

Curve A is the correlation curve between the data obtained at R_A and the data obtained at the rear horns. Curve B is the correlation curve between the data obtained at R_B and the data obtained at the

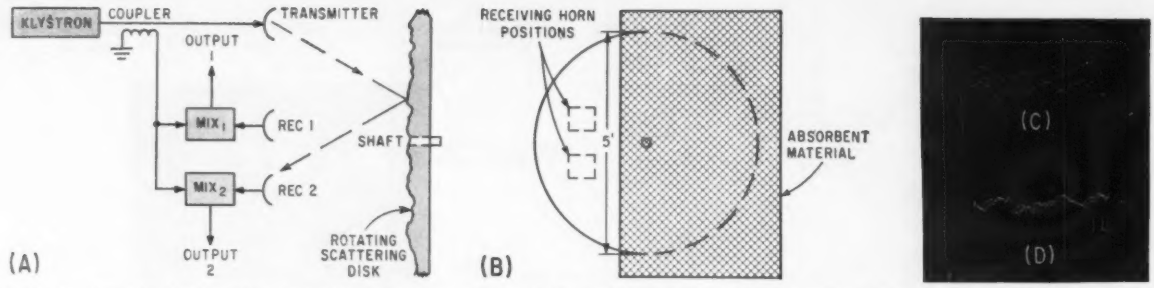


FIG. 5—Correlation navigator microwave test set-up (A) and front view of scattering disk (B); oscilloscope trace of the two independently detected backscattered signals (C and D)

rear horns. The value of τ is determined by switching alternately between the two curves and detecting an error voltage signal. At a delay time of τ_A where the separate correlation curves cross, the error signal goes to zero and the ground speed can be accurately measured as a function of τ_A. Note, however, that the value of S to be used in Eq. 1 now becomes the equivalent S as indicated in Fig. 2D.

The constantly changing nature of the sea surface introduces a decorrelation function which is directly proportional to the relative delay time between the lead and the lag signals. This effect is shown in exaggerated form by the dotted curves in Fig. 2E. It can be readily seen that these modified curves are no longer symmetrical and, in fact, the peak correlation points have shifted to the left. In spite of this effect, the crossover point of the two curves remains the same, and the correct value of delay time, τ_A is measured in determining the true surface speed.

In determining vehicle drift angle, the two justapositioned rear receiving horns are alternately switched at the same switching rate as the forward horns although 90 degrees out of phase. A second pair of correlation curves somewhat similar to those shown in Fig. 2E can be established by first comparing the data obtained at R_C with the data obtained at the forward receiving pair, and then comparing the data received at R_D with the data obtained at the forward pair. Again, an error detector is used to detect the difference or error signal voltage. This error signal is used in a servo loop to rotate mechanically the complete antenna assembly. When the antenna assembly axis is aligned with the surface track of the vehicle, this error signal goes to zero, and the drift angle is read out as the angular position of the antenna assembly. Determination of drift angle completes the measurement of the true surface velocity of the vehicle.

Figure 1 also shows a variable delay element. The device used is a variable speed shift register; to use this device, several other techniques are employed within the data processor resulting in a digital data handling system.

First, the detected signals are amplified and clipped, preserving only the demodulated signal phase information. The lead signal is then sampled at a rate at least several times faster than the highest fundamental frequency contained in this noise signal, and the sampled information is transmitted through the register. At the output of the register, this signal is correlated on a bit-by-bit basis with the undelayed signals detected at the rear receivers. The output of the correlator goes to an integrator or data smoothing circuit which limits and averages the random fluctuations in the correlator output. These smoothed data are used to control an electronic servo loop which regulates the sampling or shifting frequency to the shift register.

The correlation navigator will always measure vehicle drift angle and surface speed accurately if the centerlines of the system receiver antenna patterns are normal to the underlying backscattering surface. However, normal flight maneuvers and vehicle trimming actions constantly cause the receiver antenna pattern centerlines to be nonperpendicular to the underlying surface, thus resulting in measured values of surface speed and drift angle that differ from the true values. These errors in measurement are similar in nature to errors in an unstabilized doppler system and can be corrected by data stabilization for example. However, it has been found that even the uncorrected system would always have a measured error of less than 0.5 percent. An unstabilized, simple correlation navigation system with less-than-one-percent error appears feasible for many applications.

For soft lunar landings and Dynasoar recovery, the measurement of vertical velocity and altitude is important. The correlation navigator system can be implemented to provide these outputs in addition to the outputs of horizontal velocity and drift angle.

In general, a mechanically stabilized system is required to assure that the transmitted beam is vertically oriented. Through the use of pulsed transmission, altitude above terrain can be measured continuously as in other types of pulse altimeters. Ordinarily the altimeter will have a beam-limited return, and through threshold detection, a predicted accuracy of ± 150 meters at an altitude of 300 kilometers can be obtained in spite of an assumed moderately rough terrain. Over smoother terrain, accuracy would be proportionately better.

Vertical velocity could be obtained by a determination of altitude rate but studies show that a three-axis receiving antenna array can be used in determining all components of velocity directly through the correlation technique of data processing. One preliminary receiving antenna array for such an application (Fig. 2F) consists of a triangular array of three dielectric type receive antennas in the main antenna plane with a fourth dielec-

tric type receive antenna displaced vertically along the perpendicular to the centroid of the triangular array. By cross-correlating the signals received among the various pairs of antennas, the horizontal and vertical components of velocity can be separated out in much the same way as is done in present doppler systems, while retaining the simplicity of the correlation technique. Figure 2F does not show the single transmitting antenna since its positioning is not critical.

An experimental correlation Navigator radar was flight-tested in a small aircraft. Figure 3A diagrams the radar that was flight-tested. The transmitting horn was physically displaced an appreciable distance from the receiving horns, and one of the two receiving horns could be moved forward or backward or from side to side. Two receivers, consisting of synchronous detectors and audio amplifiers were used and their outputs were applied to a multiplier circuit. A rotary phase shifter caused correlation between the receiver outputs to be evidenced as a 60 cps voltage at the output of the multiplier rather than as a change in d-c level. Low audio frequency components, produced by the c-w transmitter leakage, were removed by 200-cps high-pass filters.

Space normally used for the rear seat was used for the correlation navigator equipment (see Fig. 3B).

The transmitter operated c-w at X-band with a power output of 100 milliwatts. Antennas were horns with 2¼-inch by 3¼-inch openings. An L-C audio frequency delay line was used in the forward receiver, and correlation was measured as a function of antenna spacing while the aircraft maintained constant heading and airspeed. The correlation should have been a maximum when the centers of the two receiving horns were aligned in the direction of motion, and the spacing between the centers was equal to twice the distance that the aircraft traveled during the delay time, the delay being applied to the output of the leading antenna.

To check this relationship, a flight was made along a calibrated section of railway tracks and the data on output vs antenna spacing plotted in Fig. 4A was obtained. At the same time, the speed was checked by noting the time of passing various structures at known distances along the track and plotting the result. Two runs were made: the first westbound, the second eastbound. The peaks of the curves agree quite well with theory.

A calculated curve of cross-correlation as a function of separation is shown (Fig. 4B) for comparison with the measured data. The time delay is 1.188 milliseconds, the value used in the tests. The speed assumed is 105 mph; at higher speeds, the entire curve is simply displaced to the right.

Later laboratory tests were made using the microwave system shown in Fig. 5A and 5B. For these experiments, a low power klystron transmitted a c-w signal toward a 5-foot diameter rotating wooden disk. The surface of the disk was dotted at random with different sized pieces of aluminum foil to provide a backscattering surface.

The backscattered energy was detected by the two receivers and synchronously detected directly to the doppler spectrum modulation. These two signals were then observed on a dual trace oscilloscope. Figures 5C and 5D shows a representative oscilloscope picture. Figure 5C shows the separate time synchronized traces of the two signals and Figure 5D is a later time synchronized presentation of the two independently detected signals superimposed upon one another. Figure 5D shows especially well the similarities between the two signals and the time displacement between them.

These experiments were carried out for various rotor speeds; in all cases the experimental data agreed with theoretical predictions within the limits of the test set-up.

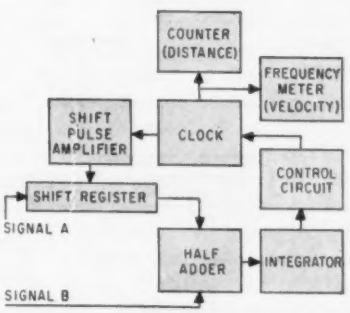


FIG. 6—Simplified velocity and distance data processor

Figure 6 shows a data processor for the correlation navigator. The demodulated and clipped lead signal, signal *A*, is sampled by a standard shift register and propagated through the register to one input of the half adder. The demodulated and clipped lag signal, signal *B*, goes to the other input of the half-adder. The half-adder is simply a binary device that gives an output signal if both input signals are of the same polarity, and no output signal if the two input signals are of unlike polarities.

The degree of coincidence or correlation between the two input signals can be measured as a function of the time-averaged output voltage from the half-adder circuit. If the input signals were a periodic function, the output from the correlator could be reduced to zero by shifting the phase of one input signal 180 degrees with respect to the other. However, this cannot be achieved for a random signal since the phase angle between the two signals is continuously changing (except when they are locked in phase) and the averaged voltage output from the correlator will approach $e/2$ instead of zero volts.

The output of the integrator (Fig. 6) provides the driving signal for the control circuit which in turn varies the clock, or shift, frequency in a manner to maintain peak signal correlation.

The control circuit is critical to the system operation and both analog and digital techniques have been studied in this connection. The most accurate control circuit investigated employs digital techniques and two shift registers. In this circuit the error signal from the integrator is used to update a recirculating register, which in turn controls a second register. The overflow of the second register actually is the clock and provides the input signal directly to the shift pulse amplifier. Accuracy is limited only by the number of stages used in the two registers. The frequency of the clock is a measure of ground speed and the time integration of this frequency provides distance information.

REFERENCE

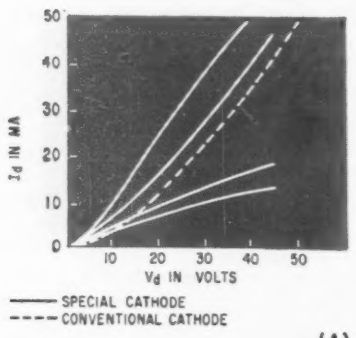
F. R. Dickey, Jr., The Correlation Aircraft Navigator, A Vertically-Beamed Doppler Radar, National Conf Proc, Aeronautical Electronics, Dayton, Ohio, 1958.

Latest Developments in

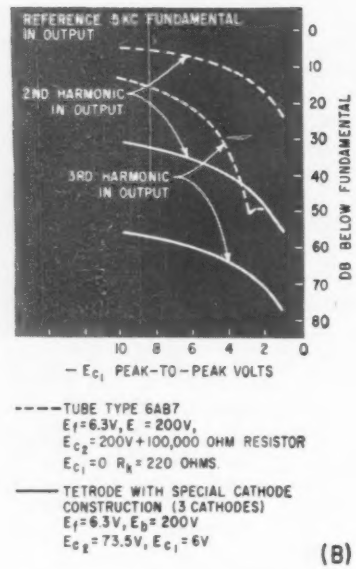
New tubes include ultralinear tubes using multiple rectangular cathodes, low screen-grid current tetrodes using collimated beams and high-gain video amplifiers

By LESLIE SOLOMON,
Associate Editor

SOME of the latest developments in circuits and electronic devices for the home-entertainment devices were given at the Radio Fall Meeting, sponsored by the EIA Engineering Department with participation by IRE professional groups, held in Syracuse, New York, between Oct. 30 and Nov. 1, 1961.



(A)



(B)

FIG. 1—Curves show special cathodes at different spacings compared with conventional cathode (A). Harmonic analysis shown at (B)

One problem often encountered in receivers is distortion of the signal by high-level undesired signals from other transmitters.

Within the receiver, interference from undesired signals is caused by curvature of the tube characteristics. To solve this interference problem, it becomes necessary to linearize the transfer characteristics of the input tubes (especially in sensitive receivers).

An ideal input tube should be capable of handling an undesired signal of at least 10 v peak-to-peak without generating serious interference, should be workable to at least 200 Mc and if possible to 400 Mc, the noise figure should be about 10 db for 200 Mc. Transconductance does not have to be high. Amplification should be just sufficient that the first stage can establish the overall noise figure (a little over one). However, the gain must not be so high as to overdrive the next stage with the undesired signal. The desired signal can then be amplified and the undesired signal attenuated in the following stages.[1]

To suppress both cross modulation and intermodulation, the tube characteristics must approach a straight line. A quadratic characteristic will suppress cross modulation only. The variable pitch tubes commonly used can never completely suppress the interference. The transfer characteristics of such a tube consists of the sum of all the characteristics of the pitches, which are all three-halves power curves. Consequently, the sum of these curves can never be a straight line. One approach is to use only the top part of the transfer characteristic as it is more linear than the bottom.

A cathode construction, consisting of two or more rectangular cathodes mounted in a row next to each other and coated with carbonates only to the sides that face each other, can produce almost straight-line curves. At the moment, there is no explanation of the phenomena introduced by this cathode configuration. Figure 1A shows some characteristics of a diode developed at Westinghouse compared to a conventional diode. All tubes were aged and curves were made using 6.3 v (approximately 725 C cathode temperature) on the filaments. The conventional cathode shows a three-halves power curve while the new cathode configuration closely approaches a straight line. Where they are not straight, they follow a 1.25-power law.

Several experimental triodes and tetrodes were built using the new cathode. The tetrodes were made with three cathodes and lined-up

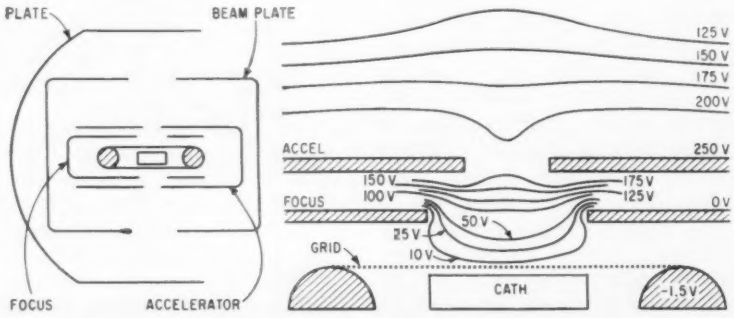


FIG. 2—Collimated beam tetrode and associated field plot

Electron Devices

grids to reduce screen current. Figure 1B shows the result of harmonic measurements compared with a conventional 6AB7.

A tetrode was used in a communications receiver in place of the 6AB7 and a desired signal of 140 μv of 4.1 Mc, 30-percent modulated with 1-Kc audio with an undesired signal of 10 v peak-to-peak, 3.95 Mc, 30-percent modulated with 1-Kc audio as composite input.

With the 6AB7 and the new tetrode, the level produced by the undesired signal was + 2 db the output produced by the undesired signal was — 0.6 db for the 6AB7 and — 28 db for the new tetrode. The effect of agc, noise and other factors are still unknown.

The desire to obtain most of the characteristics of a tetrode or pentode without the useless and objectionable flow of screen-grid current has existed since the concept of those structures. Reducing the screen grid current results in a noise figure substantially that of a triode. Although focused electron beams with zero first accelerator currents have been used for some time in cathode-ray and special-purpose tubes, their use in the collimated beam tetrode, the DT-805H, results in near idealized pentode characteristics useful into the vhf spectrum.[2] This new design, originated by Tung-Sol Electric Inc, results in a plate family with sharp knees and low knee voltage around 50 v, a screen-to-plate ratio of 2 percent, noise figure compared to a cascode triode, transconductance of 10,000 μmhos or more, gridplate capacitance of 0.02 pf and plate resistance of one-half megohm.

Figure 2 shows the construction of the tube. Adjacent to the cathode is a frame-type control grid. Between the control grid and anode are three separate slotted electrodes. There are the focus electrode, the accelerator (screen grid) and the suppressor beam plates. The beam focusing design eliminates lateral wire alignment between control and screen grids thus this design has only one wound grid. To obtain high transconductance and low noise, a uniform accelerating field is presented to the cathode over a wide area. Figure 2 also shows a field plot of the structure and indicated the field configuration that maintains the low accelerator current essential for low noise figure.

The DT-805H compares in performance with a cascode-connected 6BQ7A and has a noise figure superior to r-f pentodes. The tube can handle an interfering signal level of over 350 mv at any bias while a recently introduced vhf frame grid triode (6ER5) can be used with no higher than about 100 mv interfering signal, both for 1-percent cross modulation.

Continuing efforts to simplify tv receiver design to obtain greater picture contrast has steadily increased the burden of the video amplifier. Reducing the number of i-f stages makes the tuner, remaining i-f stages and video amplifier make up the loss of gain. The introduction of strap frame grid i-f amplifier tubes such as the 6EJ7 and 6EH7 permits a substantial increase in gain per stage. However, this may not be sufficient to compensate for the elimination of one stage in a three i-f stage receiver. Some loss can be made up by narrowing the bandpass of the remaining i-f amplifiers or by operating the tubes near their maximum ratings. To improve the gain of a conventional video amplifier, the plate load can be increased to the point of losing the higher video frequencies, or a higher plate current tube with an increase in plate and screen supply voltages can be used.

To meet these objectives, Sylvania has developed a strap frame grid triode-pentode video amplifier that permits removal of one i-f stage, due to its high output with relatively low input.[3] The SR-2926, the new video amplifier, has a high g_m/ma ratio and a low knee voltage that results in less voltage drop at peak signal. This permits higher output at lower plate and screen dissipations and the high efficiency in that less screen voltage is needed to produce a greater plate voltage swing.

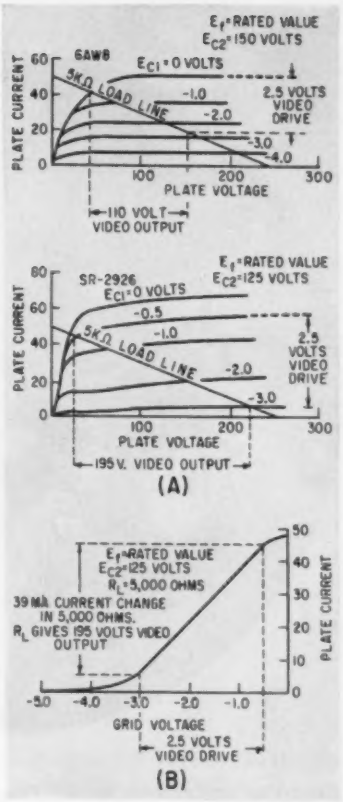


FIG. 3—Comparison of SR2926 with 6AW8 plate family curves. SR2926 transfer characteristic (B)

The family of curves shown in Fig. 3A shows a typical video amplifier 6AW8 compared with the new SR-2926.

The transfer curve for this tube is shown in Fig. 3B. It combines a broad linear operating range with a sharp cutoff characteristic. This is important in video to prevent sync compression in the cutoff region. Saturation of the curve near maximum current is due to the plate load resistor. This can be corrected by decreasing the screen voltage, which would lower the zero bias plate current to where the plate load intercepts at the knee.

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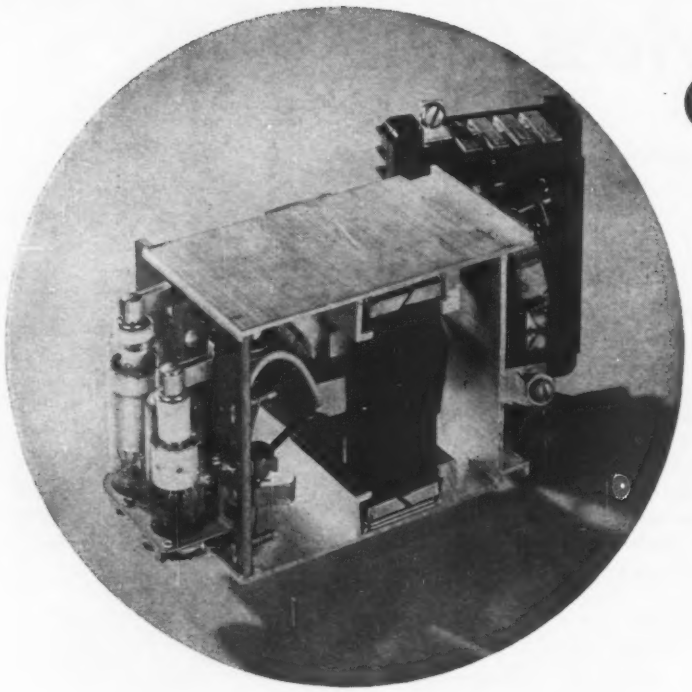
Gas Tubes and a

Practical electronic ignition system has features which improve engine performance over conventional systems. Makes new high-speed engine design possible



Electronic components of the Tung-Sol EI-IV electronic ignition system consists of two separate units. Thyratron and cold cathode rectifier are mounted on the main unit; transistor and heat sink are separated to avoid effect of engine heat

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ELECTRONIC IGNITION systems should, ideally, be compatible with standard distributors, spark plugs, breaker points and battery supply. In addition, an electronic system must provide substantial operating advantages over conventional systems. For example, with a properly designed system, there should be no reason to change spark plugs, breaker points or adjust engine timing for the life of the vehicle. To meet these requirements, a practical electronic ignition system using a thyratron, cold-cathode rectifier and a transistor has been developed. It operates from a standard automotive battery without additional power supplies.

The system is characterized by three major differences over the conventional ignition system: first, breaker points carry only a control current. This is so low, less than 10 percent of conventional breaker current, that burning, pitting and erosion appear to have been entirely eliminated. It is possible to use smaller gaps and to reduce the effect of contact bounce at high engine speeds. Second, a steep wave-front obtained from a capacitor discharge is supplied to the spark plug. Breakdown voltage is reached in 1 to 2 μsec as compared to 70 μsec in the conventional system. As a result, no matter how badly a plug may be fouled, the steep wave-front causes effective firing each time. This sharp rise prevents changes in timing that could reduce engine performance at high engine rpm. Finally, the entire circuit incorporates short time constants so that there is negligible reduction in firing voltage at the maximum speed of existing spark-ignition engines.

In the circuit of the electronic system, Fig. 1, the high voltage lead to the distributor is at the right. When the cold-cathode thyratron V_2 is fired, capacitor C_1 discharges through the spark coil T_2 to the plugs. Since this capacitor is normally charged to a value between 1.5 and 1.8 Kv, the turns ratio of the coil and hence the impedance of the discharge circuit as seen from the plug are quite low, thus permitting a 1 to 2 microsecond peak on the firing pulse. The thyratron is triggered to fire on the opening of the breaker points; this action also initiates the sequence that restores the charge on capacitor C_1 for the next firing cycle.

The points close for the first time when the engine is cranked for starting. Since there is no charge on the firing capacitor initially, the first plug will not fire. However, this is the extent of the delay or warm-up required. This first closing does cause transistor Q_1 to conduct and the control current flows through limiting resistor R_2 to the base. The charging current, which

Transistor for Electronic Ignition

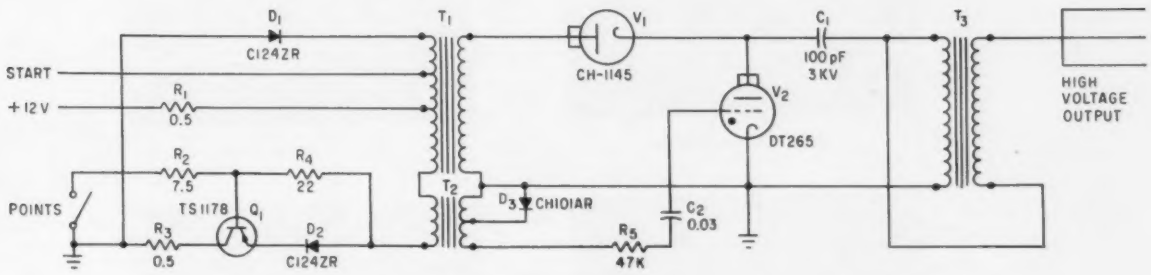


FIG. 1—Thyratron V_2 discharges capacitor C_1 through spark coil T_3 to provide ignition spark

is roughly ten times the control current, then flows through R_1 and R_3, as well as the primary of transformer T_1 and the transistor. This current builds up magnetic flux in the transformer and maintains that level until the next firing cycle.

After a dwell period equal to that in conventional ignition, the points open, the transistor becomes nonconducting, and the magnetic field of the transformer collapses. This raises the voltage on the transformer secondary and the anode of gas diode V_1 until the latter starts conducting, thereby charging firing capacitor C_1. The next closing of the points re-establishes the transistor current in the transformer primary.

When the points open again, the transistor stops conducting. Cessation of primary current causes the magnetic field to collapse, producing a high voltage spike on the secondary of both the main power transformer T_1 and the small trigger transformer T_2. The voltage on T_2 causes thyratron V_2 to fire and discharge capacitor C_1 through the coil into the spark plug in about 3 μsec. The resulting reduction of voltage on the cathode of rectifier V_1 causes this tube to conduct and charge the capacitor. The buildup of voltage on the capacitor is sufficiently slow to permit the thyratron to deionize fully before the anode potential becomes positive. This cycle is repeated at each opening and closing of the breaker points.

The remaining components provide limiting and protective functions. Resistor R_2 limits the control current. Resistors R_1 and R_3 together prevent an undesirable voltage distribution on the transistor and establish the proper charging current in the transformer primary. Diode D_1 limits the surge voltage of the transformer after the points open, so as to protect the transistor. Diode D_2 prevents the thyratron from conducting dur-

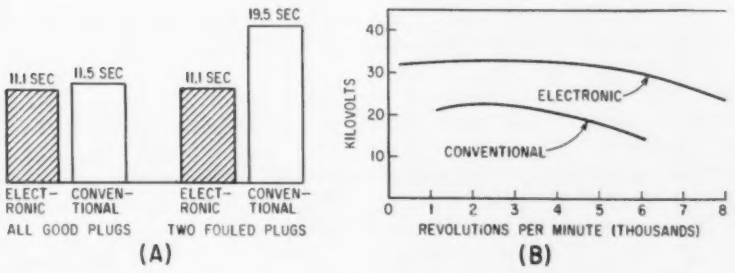


FIG. 2—Laboratory tests simulating running conditions of conventional and electronic systems show difference in acceleration time (A) and comparison of voltage fall-off at high engine speeds (B)

Electronic ignition systems have been talked about since 1945. But a really practical device could not be developed because vacuum tubes would not stand the environmental conditions to which this equipment is subject. Power transistors in high enough ratings were not available until a few years ago, so that even semiconductors did not permit development of a practical ignition system until recently. Tung-Sol's system will be available commercially in the spring of 1962

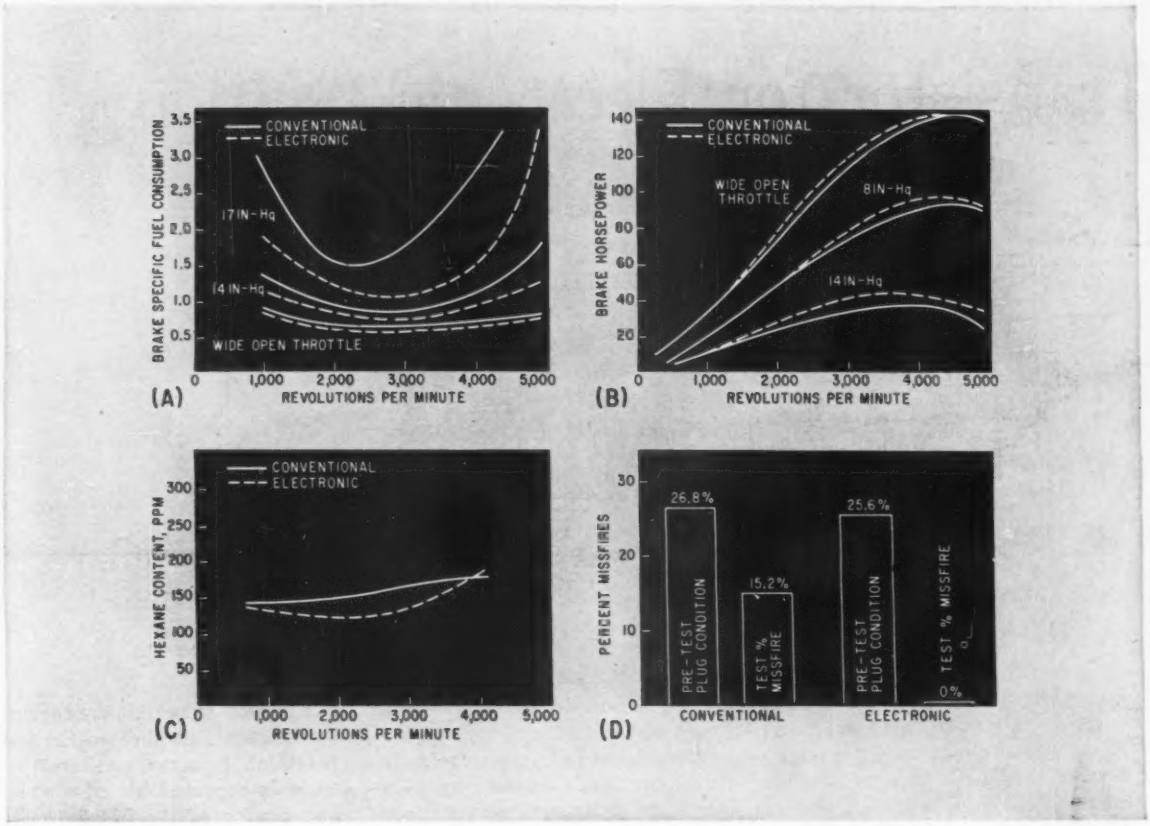


FIG. 3—Results of dynamometer tests of a conventional V8 engine equipped with both electronic and conventional ignition systems show the difference in gas consumption (A), horsepower (B), exhaust analysis (C) and misfires at full throttle (D)

ing the charging portion of the ignition cycle. Diode D_2 provides emitter bias to the transistor to limit leakage current at high temperature. With this bias the transistor will provide satisfactory operation up to its maximum junction temperature rating of 212 F.

During cranking the battery is connected to the START terminal (Fig. 1) by means of the ignition switch or relay. This permits full firing voltage to be applied to the plugs even if battery voltage should drop to 6-v because of starter drain. As a result, the system has excellent cold weather starting characteristics because of the high voltage maintained by means of the starting tap. Also, the points carry only control current and do not "blue" as a result of long dwell time on cranking.

In laboratory tests an electronic ignition was operated through more than 250,000 miles of equivalent driving without trouble. By comparison, a standard system showed a series of failures up to 165,000 miles, at which point it failed completely. Perhaps most significant is the comparison of operation under fouling conditions, shown by an acceleration test in Fig. 2A, and the fall-off in voltage with engine speed, shown in Fig. 2B.

Dynamometer tests with a standard V8 engine show fuel consumption vs engine speed, Fig. 3A, while Fig. 3B shows improvement in brake horsepower delivered to the dynamometer. The tests, indicate that electronic ignition can convert up to 6 percent more of the energy available in the fuel to mechanical energy. Consequently, there are less unburned hydrocarbons in the exhaust gases, Fig. 3C. It is reasonable to expect that up to 25 percent more brake horsepower can be obtained from the electronic system with fouled plugs, for equivalent speed and fuel consumption conditions. Fig. 3D shows the percentage of misfires at full throttle for the two systems using fouled plugs. With new plugs, the electronic system had fewer misfires.

On one test run with two similar trucks, gasoline mileage increased more than 20 percent with the electronic system during 30,000 miles of operation.

When installed on a 2-cycle outboard motorboat engine that was particularly susceptible to trouble with fouled plugs, the electronic ignition system operated with plugs that could not be fired at all by conventional ignition.

Credit is due to W. Buchanan, E. Howland, J. Kuykendahl, R. Schellhorn and M. Yarmovsky for contributions to circuit and tube design.

MEDICAL ELECTRONICS

Part VI: Observing Life Processes

Improvements in microscopic examination of living matter through use of closed-circuit television and electronic measuring, scanning, analyzing and computer techniques

By WILLIAM E. BUSHOR
Senior Associate Editor

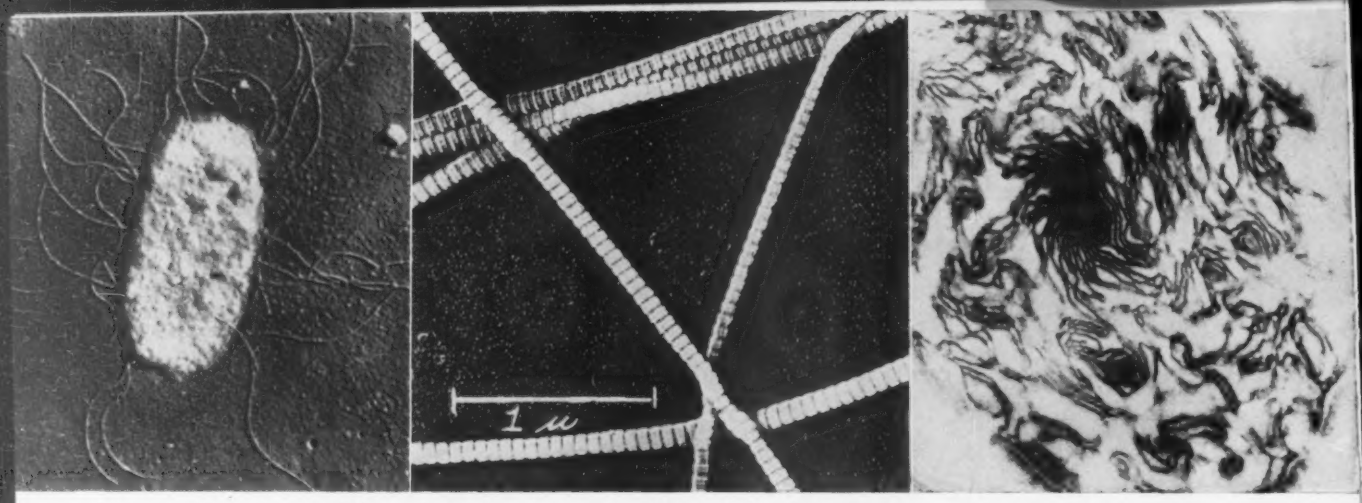
MOST SIGNIFICANT contribution electronics is making to medicine may be in experimentation and research. This article will discuss the electronic laboratory tools and techniques being used to microscopically probe and study our biggest enigma—the life process itself.

Optical-tv Microscopy—Visualization of a biological specimen containing particles of microscopic proportions has required the development of image amplifying systems. The optical microscope together with an optical microprojection arrangement has long been used for this. However, the intense light required for illumination often heats the specimen too much. This problem is overcome using closed-circuit tv coupled to the microscope, and the added advantage is given of permitting an unlimited number of pathologists, biologists, researchers and the like to examine the enlarged view of the specimen simultaneously and at remote locations, if necessary. Also, it has been found particularly advantageous to use such systems in observing living organisms, especially with the phase contrast technique wherein objects that differ in optical path are made visible.

Practical examples are two integrated optical microscope-tv systems recently made available by Elgeet Optical Co. that can produce magnifications up to the lower limits of low-priced electron microscopes. The tv cameras used are single, self-contained units whose video signals are routed to a tv monitor, usually with a 17-inch screen. One system, using Sylvania Electric Products' electronic units, gives magnifications up to 2,500× with 300-line resolution. The other, using Allen B. DuMont Labs' units, gives magnifications up to 3,500× with 600-line resolution.

Development of cathode-ray tubes with fiber-optic faceplates by a number of companies may eventually enhance characteristics of the tv monitors. When the electron beam excites the phosphor on the back of the faceplate, the resulting light is conducted to the front by millions of optical fibers that are made of some form of dielectric ma-

Electron microscopes like this RCA unit give researchers a powerful tool for visualization of particles as small as 1/20,000,000 inch



Micrographs made with RCA's electronic microscope. Left to right: bacteria, human collagen, snail sperm, tobacco

terial. Advantages of these tubes to the microscopist are that parallax is eliminated, light transmission efficiency is increased and brighter or more magnified images can be obtained by using tapered fibers. Cost is expected to inhibit their use in the immediate future.

Electron Microscopy—This technique provides 200 times the resolving power of compound light microscopes because the effective wavelength of the electron beam is only 1/100,000 that of visible light. This shorter wavelength permits objects such as viruses to be viewed in detail which are hidden by diffraction of light in optical instruments. Unfortunately, the full resolution theoretically possible with electron beams cannot be realized because electron lenses are much inferior to optical lenses. Theoretical and experimental resolution limit is still 8 to 10 Angstroms despite 0.05 Angstrom wavelength of an electron beam.[1]

There are two general types of electron microscopes: those requiring the viewed object to emit the electrons and those that generate the electron beam themselves. Since the former have little or no medical applications, only the latter types will be discussed here.

Illumination in electron microscopes is provided by an electron beam focused with an electron lens to irradiate a thinly sliced specimen. Since absorption of electrons is proportional to the density at any given point, the concentration pattern of electrons passing through forms a shadow-like image of the specimen's structure. After being magnified thousands of times by another electron lens, the electron image impinges on a luminescent screen or photographic film, depending on whether immediate viewing or a permanent record is desired. Most electron microscopes use magnetic focusing lenses.

Although functionally an almost exact counterpart of optical microscopes, electron microscopes are physically dissimilar. They must operate in a vacuum and generate high accelerating potentials. Also, good electronic images can be obtained only if specimens have sufficient atomic density contrast. However, just as with optical systems, three-dimensional images can be obtained using stereoscopic viewing or metal-shadowing techniques. Electron microscopes require tissue preparation techniques different and more exacting than those used with optical instruments. New materials and section-cutting machines (microtomes) are required.

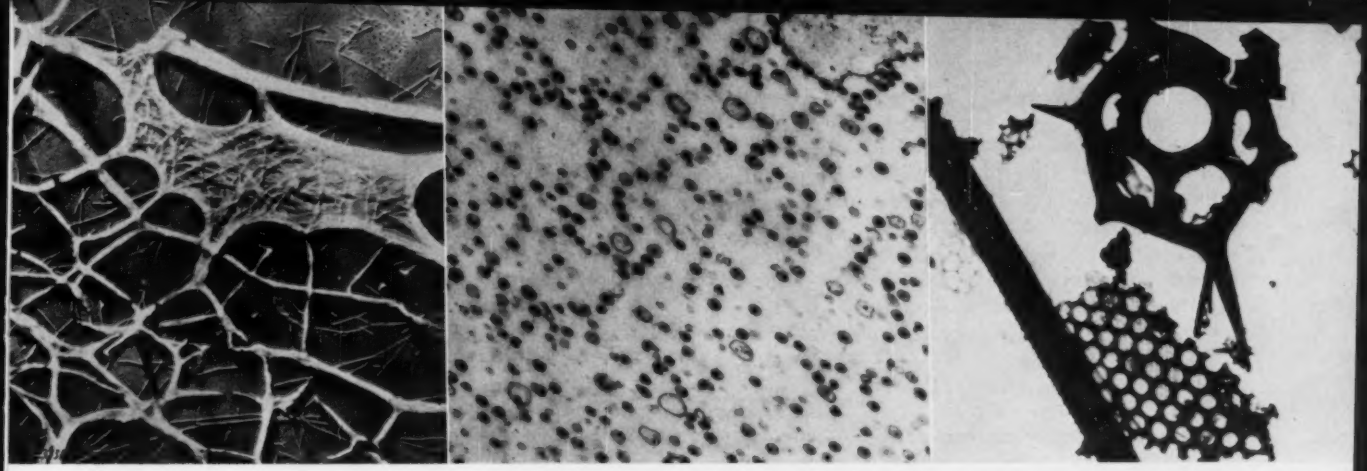
Research into the causes of rheumatism and arthritis has prompted the development of an electron microscope that can magnify an image 150,000 times. The instrument is being used at St. Thomas' Hospital Medical School in London. A cell measuring only one-thousandth of an inch can be blown up to a 15-inch diameter, thus permitting study of the structural detail of cartilage cells. Ordinary compound microscopes previously used had only a 1,000 magnification factor. Main problem the researchers are having is interpreting the image. This is because ordinary microscopes show hundreds of cells in the same field, while the electron microscope shows only a portion of a cell thereby leading to difficulty in identifying the cell itself.

Electron magnifications ranging from 2,000 × to 30,000 × have been obtained by Hitachi of Japan through use of a three-stage permanent-magnet lens system. Reportedly, resolving power extends down to 15 Angstroms. By using a permanent-magnet as the lens exciting source, no hysteresis effect is produced by opening and closing the 50-Kv power circuit as would be the case with electromagnetic lens excitors. Objective and projection lenses are single-gap devices while the condenser and intermediate lenses are double-gap devices.

A major disadvantage of electron microscopes is that the high vacuum required oxygen-starves and dehydrates the specimen. By the time the slide can be viewed, what was initially living matter has died and even changed its physical form.

Living bacteria have been photographed, however, at the National Center for Scientific Research in France using a 1.5-million-volt electron microscope to provide magnifications up to 25,000 ×. Biological specimen is held in a hollow container 0.1 cu mm in volume and exposed to normal atmosphere. The scanning beam, admitted through 0.1-micron thick windows, is boosted to nearly the speed of light by 750 to 1,000-Kv acceleration voltages. After exposure in the microscope, the bacteria in the cultures have reproduced.

Field ion microscopes, which have recently come into existence, produce ion beams with significantly



plant virus, mouse cancer virus and diatom (algae) fragments. Specimens were only 1/500,000 of an inch thick

shorter wavelengths than do the electron beams in the electron microscopes. The advantage in resolution thus obtained has been used to photograph an individual atom on a metallic surface. However, investigation revealed no applications of this instrument to medical or biological research.

X-Ray Microscopy—Through international agreement, techniques for enlarging images using x-rays has been called x-ray microscopy; these include contact microradiography projection microradiography and x-ray microscopy by total reflection. Although only the last is a truly microscope-type instrument, the others are of importance as research tools.

In contact microradiography (also called historadiography) the specimen is brought into contact with a fine-grained photographic film during exposure to x-rays. Because of this intimate pairing, the radiogram is the same size as the specimen, thus enlargement is necessary using a light microscope.[3] Optimum resolution obtainable with this technique is limited by the fineness of the photographic film. The geometrical blurring caused by short depth of focus can be controlled through use of thin emulsions and specimens.

A new kind of x-ray film developed by researchers at Stanford U. has enhanced microradiography by giving four times sharper images than previously obtainable. This facility should give scientists a look at the nucleus of a cell. Used with an electron microscope, magnifications of 40,000 diameters can be obtained because the film resolves details to less than 600 Angstroms where best previous resolution was 2,000 Angstroms. The film is made by casting 1/250,000-inch thick layer of nitrocellose mixed with a silver compound into a glass surface.

In projection microradiography (also called projection x-ray microscopy, geometric x-ray microscopy and x-ray shadow microscopy) the image is preenlarged by displacing the film with respect to the specimen. Thus, the divergent angle of the x-ray beam originating from a small focal point geometrically magnifies the specimen's shadow image. This approach is limited by geometrical blurring caused by the requirement for an ultrafine focal spot. With electron lenses (usually electromagnetic) to focus the x-ray beam, considerable reduction in focal spot size (and thus increased resolution) is obtained. Electrostatic lens systems are being experimented with but do not give high enough resolution. Although photographic enlargement is possible, the 10 to 100 times magnification obtained usually makes this unnecessary. Since depth of focus is larger, thicker specimens can be used than with contact microradiography.

A projection microradiograph for cancer tissue studies has been developed by the Central Organization for Applied Research in the Netherlands. This instrument provides binocular viewing either of the specimen or of its fluorescent image. Also, four types of target materials are used that can be interchanged during operation.

In x-ray microscopy by total reflection the image is formed as with the light microscope. Because lens systems for x-rays are not practically feasible, the beam is bent by reflection from curved mirors or by refraction from crystal surfaces. Resolving power depends on the wavelength of x-rays. Advantage of this instrument is that it can be used backwards to produce a narrow beam of high intensity for microdiffraction or microfluorometric studies. Unfortunately, the x-ray mirrors used in a laboratory model of a reflection system were found difficult to manufacture and adjust.[3] Lack of suitable refractive material has held back development of this system.

The Russians recently reported that their Machine Building Institute has constructed an x-ray microscope with a magnifying power of 2,000 diameters. No further details were available.

Ultrasonic Absorption Microscope—An ultrasonic absorption microscope that produces high-resolution images for investigating the microstructure of biological systems has been evolved at the U. of Illinois[4]. Using light or electron microscopes, many structural components of biological materials may not be detected at all; however, if these substances have different acoustic absorption coefficients, ultrasonic microscopes will differentiate between them. Because some different types of protein molecules at equal concentrations absorb sound at different rates, this instrument should be useful in determining spatial distributions in and identifying types of protein in tissue.

Rectangular, 0.1-second pulses of

12-Mc sound generated by a piezoelectrical crystal are used to irradiate the specimen, which is imbedded in a liquid having the same acoustical impedance. This ultrasonic energy is partially absorbed by the specimen, the remainder passes through it exciting an iron-Constantin junction thermoelectric probe behind and adjacent to the region being investigated.

The electrical output of the probe is fed through a d-c amplifier to the vertical deflection plates of a crt. Thus, beam deflection magnitude is a measure of the relative amount of acoustic energy detected by the probe. Deflection changes resulting from moving the specimen toward and away from the sound source, are recorded and then plotted to give a picture of the disturbance to the sound field distribution caused by the specimen.

Ultraviolet Microscopy—If an ultraviolet source is used for illumination, previously unsuspected differences in the chemical and optical properties of specimens are sometimes revealed. Photomicrographs made with ultraviolet light have greater contrast than those made with white light, resolution being greater because of shorter wave lengths involved. Also, use of uv eliminates the staining technique, which alter the specimen chemically and mechanically. This is often necessary with visible light microscopes to achieve sufficient contrast.

Living preparations, when observed against a dark field, reveal little scattering of light. Thus, uv microscopes inherently are subject to less error than light microscopes. Most important contribution of uv microscopy in this area has been the localization of nucleic acids.

Extensive use of uv microscopy has been hindered because: lenses are not apochromatic (that is, the image plane shifts with changes in wavelength), transmission through refractive elements is function of wavelength and uv light sources are not satisfactory for obtaining arc, flicker and like outputs. Furthermore, the uv image cannot be viewed directly with the eye; uv-sensitized photographic film, fluorescent phosphors, image converters and photocathode storage tubes are used as conversion mediums.[6]

Experimenters at the department of human anatomy of England's Oxford U. have used a uv microscope for directly observing the fundamental processes in living cells. The system uses a uv-sensitive vidicon tube, developed by EMI Electronics, which is fitted to the camera of a closed-circuit tv system. Various living cell preparations have been examined, including free swimming chromosomes and live sperms of mice and frogs.

A technique that has shown great promise for revealing microscopic structures in the living state is the uv color-translating tv microscope. This is a process that produces three separate visible images by successively illuminating the specimen with three different wavelengths. Color presentation indicates absorption differences not detectable on gray-scale black and white pictures except with a densitometer. When picked up on a tv camera, three sequential signals are generated, one for each uv wavelength. By synchronizing the sequenced signals with the color tv monitor and superimposing the images, a color display can be produced that corresponds to the uv absorption spectrum.[6]

This technique is being used in a uv color translating tv microscope built by the Rockefeller Institute for Medical Research from equipment donated by RCA.[7] It has been used to examine protoplasmic inclusions in streaming protoplasm (as in moving amoebae or cyclocis in plant cells), to localize colorless organic compounds like vitamin A and acriflavin which are otherwise difficult to observe, and to study uv radiation damage.

Another color translating system built by Avco's Research and Advanced Development division uses three grating monochromators, each with its own uv source, which can be set to a preselected wavelength over a range of 2,400 to 6,200 Angstroms.[8] A pair of rotating mirrors are used to sequentially illuminate the specimen at each of the three different wavelengths. The uv absorption images pass through the microscope optics and then are separated in space by a second pair of rotating mirrors. Three tv cameras receive the uv images. The uv vidicon tube in each camera is associated with a primary color that is different than that assigned the other two. By presenting a composite picture on a 15-inch tricolor monitor, differences in spectrum transmission indicating differences in chemical composition of cellular components can be determined by observing variations in hue of the tv image.

Infrared Microscopy—Infrared radiation penetrates through some organic tissues better than visible light. Differences between cancer and normal cells in thick specimens, which cannot be distinguished with ordinary microscopes, can be observed with ir microscopes. Because no directly visible images are obtained, photomicrography must be used. This instrument is well suited for analysis of minute samples of drugs, perfumes, tissues, cells, blood and muscle fiber.

The instrument consists of an ir monochromator which concentrates ir energy through a slit and optical lenses onto the specimen. An optical system magnifies the image of the specimen up to 200 times and focuses it on a detector. To avoid chromatic aberration, reflective optics are used throughout.[9]

An infrared microscope capable of distinguishing between normal and cancerous cells and revealing internal structure of bone tissue and details of the eye's iris has been developed by Nippon Electric Co. in collaboration with the U. of Tokyo. The instrument is sensitive to radiation over a range of 4,000 to 13,000 Angstroms and will magnify an ir image 1,080 times.

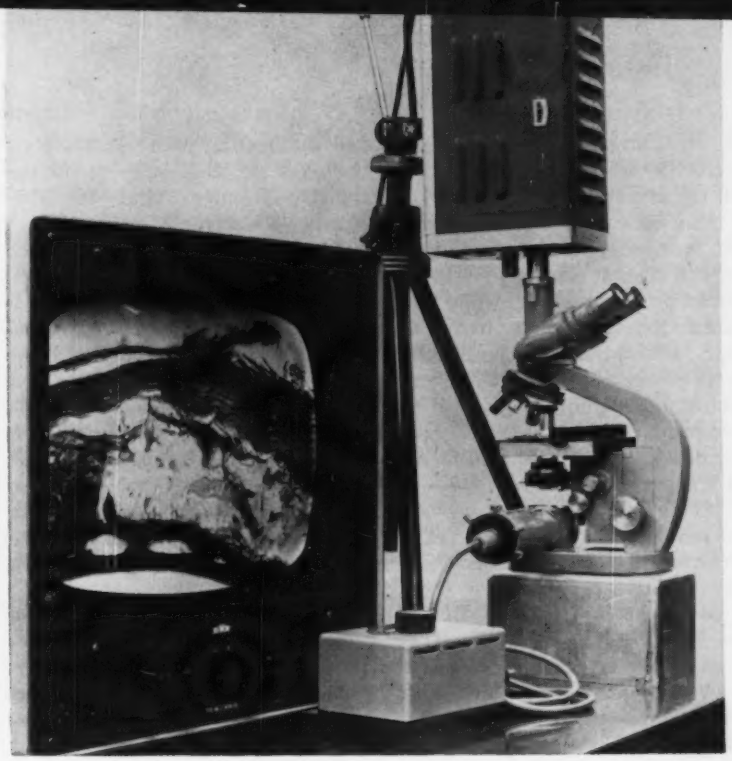
The system consists of an optical microscope, an optical system that includes an image converter tube and a light source with an infrared filter, and a 16-Kv d-c power supply. Object to be viewed is illuminated with an ir beam from the source-filter combination. An objective lens focuses the magnified ir image on the photoelectric surface of the image tube. Electrons emitted are accelerated and focused by high-voltage electrodes to produce a visible image on a phosphorescent screen. The image can be photographed or coupled to a closed-circuit tv system for remote viewing. This instrument will probably be most useful in studies connected with dermatology, ophthalmology, cytology and pathology.

Scanning Microscopy—Tv-microscope systems use conventional scanning principles to convert the image on the target in the camera tube into electrical signals. The advantage of this approach is that invisible ir and uv images can be converted to a bright visible picture of practically any size if a camera pickup tube with appropriate sensitivity is used. Unfortunately, the object being viewed is continuously exposed to illumination, a situation that could have detrimental effects on the specimen (particularly living cultures).

There is a similarity between all scanning systems. The object area is systematically examined by an element of area that is small by comparison. Light flux is converted into an electrical signal whose amplitude is proportional to the light received and whose duration is proportional to size of the object. The size of the scanning element determines the working resolution.[9] A high degree of conservation of light energy required for examination of living material with minimum exposure is offered by the time-lapse and flying-spot scanning systems.

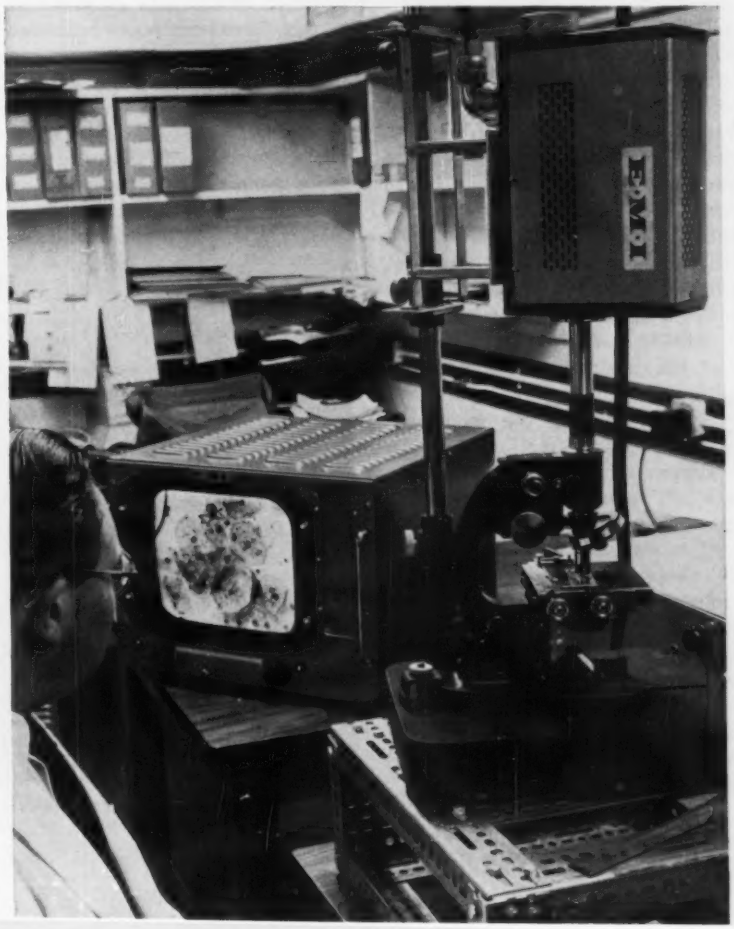
To study the progress of reactions in living cells, the National Institutes of Health and RCA have developed a uv time-lapse tv scanning system that measures the absorption products in the cell.[10] Since visualization and recording of absorption images can be done with 1/100-second exposures, cell injury from uv radiation is minimized.

A microscope with reflecting optics and illuminated by a xenon arc and quartz prism monochromator is used. A uv-sensitive vidicon is the image storing device. An automatic light shutter opens for 10 milliseconds exposing the target of a vidicon, whose electron beam has been blanked, to the uv light transmitted by the cell. When the shutter closes, the vidicon grid is unblanked and the stored image signal scanned and transmitted to a tv monitor, which displays one full frame in 33 milliseconds. It goes also to a line-selecting oscilloscope, which displays a single raster line derived from the vidicon scan signal and oriented vertically to traverse any portion of the uv-absorption image. A motion-picture camera photographs time-lapse sequences appearing on the monitor



Section of a frog's leg shown on a 17-inch monitor by combination of Elgeet's optical microscope and DuMont's closed-circuit tv

Direct observation of processes in living cells is possible with closed-circuit tv system using EMI Electronics' uv-sensitive vidicon camera tube



and oscilloscope screens. Special circuits synchronize the system with the tv vertical drive pulse.

Flying-spot uv scanning systems that spot-irradiate the specimen offer the highest efficiency of all uv microscopy approaches while requiring relatively simple circuits to obtain absorption measurements. The efficiency comes from the use of multiplier phototubes instead of photographic emulsions which need more dosage of the specimen to obtain a comparable image.

A flying-spot uv microscope has been developed at the U. of Texas Southwestern Medical School to study living cells.[11, 12] The light source is an uv-emitting flying-spot scanner having a 250-line raster that can be operated from a one-sweep-in-ten-second to one-sweep-in-1/20-second rate. By switching the raster on and off for any integral number of frames following any predetermined number of sweeps, intermittent irradiation studies can be made. Minification of the raster's image is achieved by sending it in reverse through the optical components of a reflecting microscope in which the specimen is mounted. Unabsorbed energy transmitted by the specimen strikes the photocathode surface of a uv-sensitive multiplier phototube. When amplified, the current generated by the multiplier phototube modulates a monitor tube synchronized with the uv flying-spot scanner. The black and white uv picture on the monitor represents primarily the nucleic acid absorption image of the living protoplasm. Through a beam splitter and a visible light scanner tube, the same area of the specimen can be viewed simultaneously in visible and uv light side-by-side on the monitor screen. Time-lapse motion-picture photography records the images.

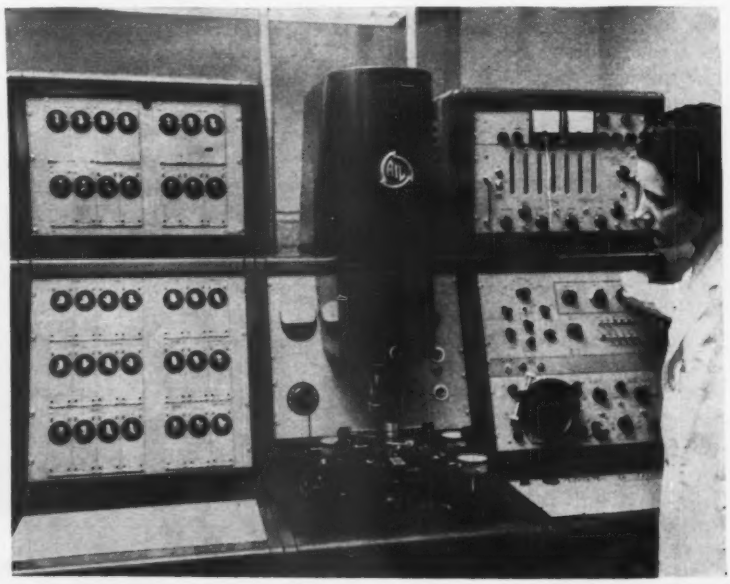
Lack of wavelength control and spectral resolution are characteristic of uv scanning tubes. To overcome these disadvantages while retaining the merits of the flying-spot scanning technique, the Institute for Cancer Research in Philadelphia began working several years ago to develop a mechanical raster generator to be used with a conventional arc lamp and monochromator light source.[13] Late last month the project was completed. A d-c xenon arc is the light source and a vibrating mirror moving on two axes simultaneously is the flying-spot scanner. Thus, the difficulties of electronic scanning—too wide a spectral bandwidth and too low a light intensity—have been eliminated. A small iris-like diaphragm in the single-prismed monochromator is the exit port for the uv beam that is focused on the specimen by achromatic optics and the sinusoidally deflecting mirror. A multiplier phototube detects the signals which are then amplified and sent to a tv monitor where an absorption image of the specimen is shown.

Cell Counters—Counting of red and white blood cells is commonly required for routine hospital admissions, diagnostic determinations and research studies. Electronics has made counting faster, easier and more accurate than manual methods. Also, the number of cells sampled is 50 or more times the amount used with manual count techniques, thus variations in count from random distribution of cells is markedly reduced. Inaccuracies caused by operator fatigue are eliminated and counts on a single specimen have been made practical.

By combining signal processing techniques with tv, quantative measurements as well as counting and measuring of particles can be accomplished. Automatic, instantaneous totalizing of particles can be done with a particle counter conceived by Bell Telephone Manufacturing Co. of Antwerp (an ITT associate). This instrument permits investigators to count bacterial colonies, and red and white blood cells and platets.

The instrument uses a closed-circuit tv system (composed of a tv camera and control unit), a monitor, synchronizing generator, an optical microscope and an impulse counter. The image of the specimen slide appearing in the optical microscope is projected on the photocathode of the tv camera. This video signal is then fed to the monitor that displays the slide on its screen. By applying an additional slower raster signal to the monitor, a series of black lines appear on the screen. When any of these lines intersect a particle, an electrical pulse actuates the counter. The optical image from the microscope is enlarged until the diameter of the particle is equal to the distance between two successive lines.

Conversion equipment permits the use of uv light, but the loss in resolving power is about 1,000 to 1,500 Angstroms. Certain bacterial cultures which contain chlorophyl are spontaneously fluorescent when



AIL's Cytoanalyzer is a combination microscope and computer capable of sensing sizes and absorption of cell nuclei (Medical Tribune Photo—Esther Bubley)

radiated with uv.

Sanborn Co. offers an optical-electronic white and red blood cell counter as a compact bench top unit.[14] The diluted sample is placed in a reservoir, the operating lever depressed and within six seconds (and for a 15-second period thereafter while sample flows through) the number of blood cells in a cubic millimeter of sample is continuously indicated on panel meter.

Use of a dark field optical system through which only the sampled solution moves insures that particles suspended are the only source from which electrical signals can be derived. Direct measurement of concentration is based on sensing flows through an inspection chamber. These are observed by a multiplier phototube. The dilution factor of the blood is such that cells are present in the inspection zone singly and only occasionally. An electrical signal is produced by the multiplier phototube for the exact duration of each cell's presence. Percent of time cells are present in the inspection volume is directly proportional to cell concentration. Thus, results are not affected by rate of flow, or cell type, size or morphology.

Blood cells can also be counted at high speeds and great accuracies for pathological purposes using the Evans Blood Cell Counter recently marketed by Racal Instrument of England. Principle of hydro blood cell propulsion permits count of white or red blood cells to be made. The quantity is read out on digital counters in millions of cells in a cubic centimeter.

Cell Analyzers—The Cytoanalyzer, developed by Airborne Instruments Laboratory under the support of the American Cancer Society and NIH, uses computer techniques to automatically read microscope slides of smears prepared from cells of body secretions to determine presence or absence of abnormal cells among the large population of normal cells.[15] Thus, obviously normal specimens are eliminated leaving only the suspicious ones for the physician to examine further. This instrument is especially useful in automatically prescreening a mass of women for cancer of the cervix —the most prevalent form of cancer and one which can be controlled if detected at an early stage.

The smear image presented by an optical microscope is converted into an electrical signal by a Nipkow disk microscanner. As the entire nucleus of each particle is scanned, a series of video pulses is produced. The duration of each pulse is proportional to the length of the nucleus chord and the amplitude of the absorption. These quantities are measured and stored by analog circuits in a cell measurer that sorts the cells according to their area by summing all the chord measurements associated with the same nucleus. The absorption data are used to reject chords with high absorption values not characteristic of true cells. An association unit with a magnetic-core shift register informs the cell measurer which chords belong with a single nucleus by using the time coincidence between the stored and incoming chords. Selection circuits determine whether or not the particles satisfy established cytological rules for acceptance as cell nuclei. Accepted particles are classified into categories by a cell sorter according to area and absorption values. Totalizers then count the number of particles falling into each category. The percentage of abnormal counts after 10,000 normal counts have been made is the criterion for labeling a smear normal or abnormal. Cancer cells from the vagina and cervix of a woman have larger and more deeply stained nuclei, and also a smaller cytoplasm/nuclear ratio.

Another cytotological analyzer using computer techniques is the new automatic blood cell scanner, Cellscan, developed by Perkin-Elmer Co. and the U. of Rochester Medical School.[16] This instrument uses digital pattern recognition techniques to determine incidence of rare cell types thus aiding in identifying small exposures to ionizing radiation.

The system differentiates between classes of white cells by counting and sizing each cell's nucleus and granules. A tv microscanner produces a binary-coded video image—a digital ONE being generated when a white cell nucleus appears in the field of view, a ZERO for all other areas of view. These binary outputs are stored in a computer that makes several sequential passes through the image data until each group of ONE's is shrunk to an isolated ONE. The number of passes required to do this is proportional to the minimum chord of the original group. By counting the number of ONE's in the memory after each pass, an image histogram is completed. This information is then converted into a plot of the total number of groups of ONE's in the original image that fall into each of several maximum chord ranges.

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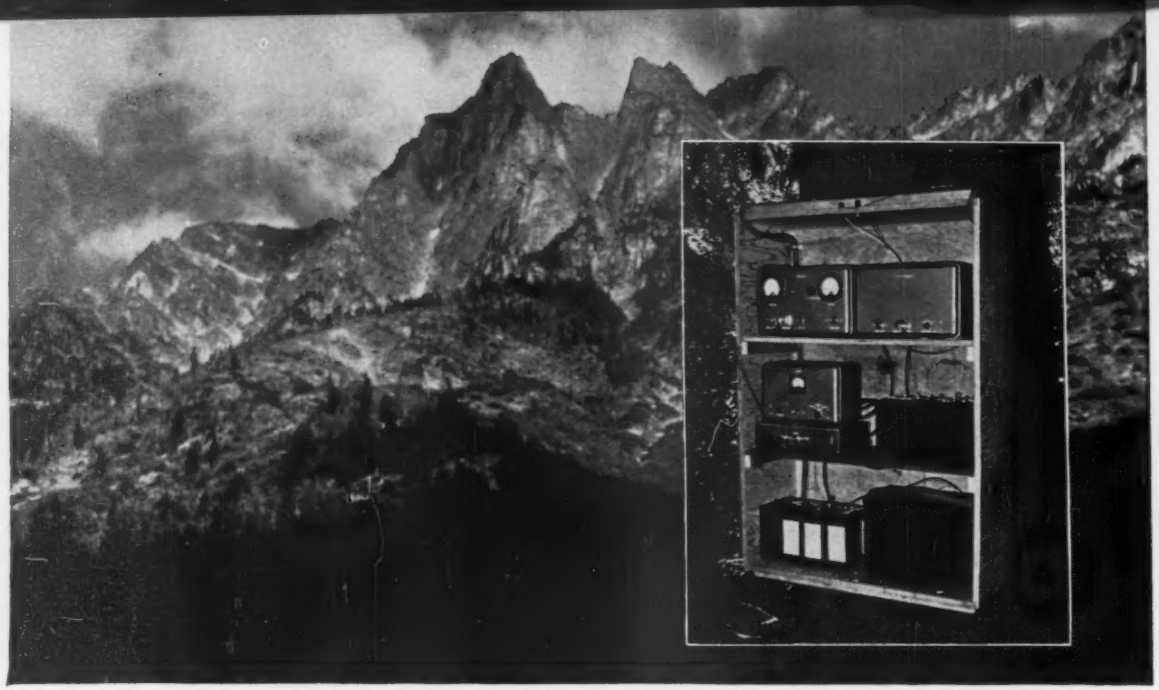

Warning system detects and reports on avalanches in areas like this one near Glacier, British Columbia, Canada

Hybrid Telemeter Detects Avalanches

System transmits tone-modulated signals to central station when wire is tripped. Frequency of modulating tone identifies station transmitting alarm

By G. NEAL
S. A. STONE
National Research Council,
Ottawa, Canada

THIS WARNING SYSTEM detects the occurrence of an avalanche and transmits the information to a central location. The transmitted information is used to alert snow removal or rescue personnel.

An avalanche detecting unit is installed at a slide path in Glacier National Park, B. C. and two more provide service along the Trans-Canada Highway.

The system consists of a tone-modulated radio transmitter located safely to one side of the avalanche path, and a receiver and recording instrument at the road maintenance camp to decode and display the signal from the transmitter. A test transmission, initiated by daylight falling on a sun switch, is sent each day to ensure that the equipment is ready.

Various types of sensors, including a light beam shining on a photocell and a pressure transducer mounted on the ground in the center of the avalanche path, were investigated.

These were rejected and the trip-wire was chosen. The trip wire consists of a pair of wires joined at the far end to form a closed circuit. An avalanche breaks the loop (Fig. 1A) to activate the transmitter.

Each transmitter is tone-modulated by a different frequency from 600 cps to 4,600 cps. Ten avalanche

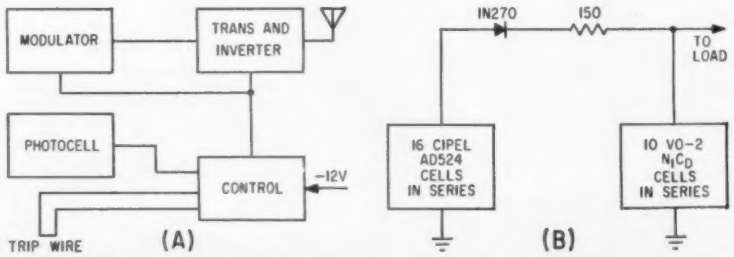

FIG. 1—Twelve-volt supply in transmitter (A) is from battery pack (B)

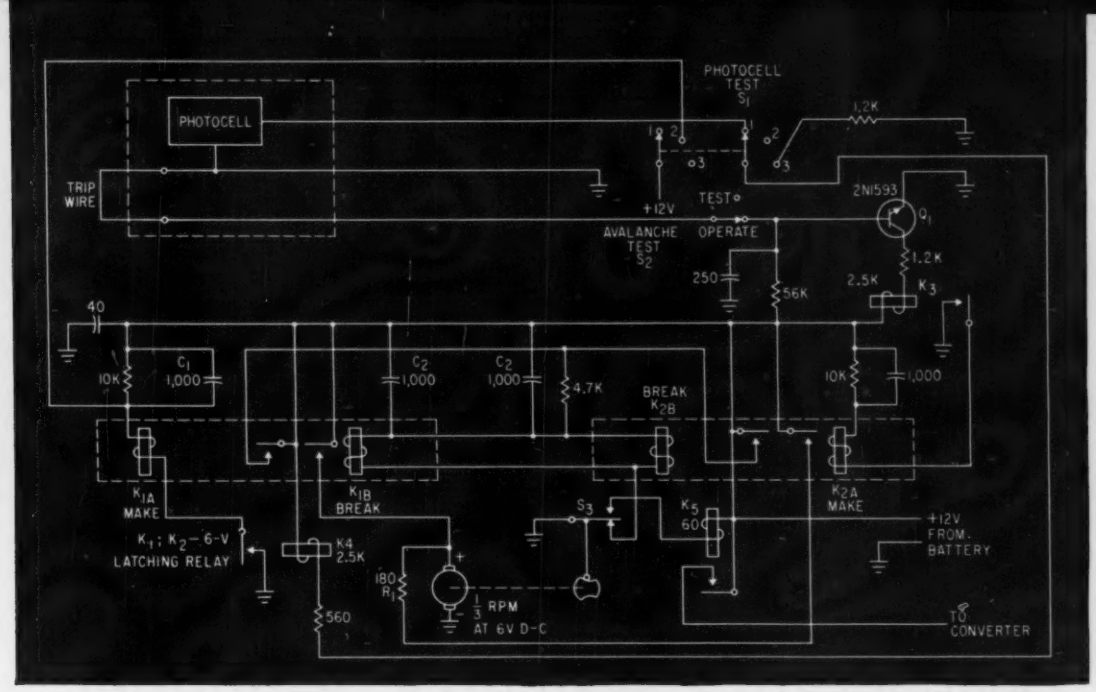

FIG. 2—Control circuit turns converter, transmitter and modulator off and on through relay contacts

paths can be monitored by each receiver.

The avalanche transmitter and modulator operates on 1,680 Kc and is all transistor, except for the final r-f stage, and delivers about 15 w into a λ/4 bent-top antenna strung between trees.

Power for the final stage is supplied from a transistor converter that changes 12 v d-c into 410 v d-c, while the rest of the system works directly from the battery.

The battery (Fig. 1B) must deliver up to 8.5 amp for about 40 sec once a day for the test signal and the same current for about 1½ minutes in case of an avalanche. It must operate in a temperature range of ±30 C and self discharging must be kept to a minimum.

The 4 amp-hr N_iC_d battery supplies low-duty-cycle high current and is trickle charged with primary cells. A single set of these batteries can provide up to seven months continuous operation.

The modulator uses a common-base feedback oscillator with a ferrite-core transformer. Two common-collector stages provide isolation and power gain. A 2N250 stage then drives a pair of 2N173's in push-pull to provide the plate-screen modulation of a 1625 tube in the final r-f stage.

Total current drawn by the modulator is metered. In addition, a portion of the oscillator output is rectified and metered to check performance.

The converter and the transmitter are built on a single chassis. A 2N274 crystal oscillator and 2N1046 buffer drive the 1625 tube. Metering of battery voltage, final current, final voltage and grid current provides for circuit adjustment at the avalanche site.

The receiving system consists of a crystal controlled fixed-tuned receiver, decoding and alarm chassis, and multipen recorder.

In the decoder, an audio tone from the receiver is passed through filters and converted to d-c. This voltage fires a thyratron in whose plate circuit is a relay that operates the pen.

The filter circuit permits identification of the avalanche transmitter from which the signals are received.

After the signal has been received for about 1 minute, a self-holding time-delay relay operates, turning on a warning light and ringing a bell. A pushbutton reset turns them off when the alarm has been sounded.

When, in the avalanche control unit (Fig. 2), daylight reduces the resistance of the photocell to a sufficiently low value, K_4 operates, and a pulse of current flows through C_1 closing K_{1A}. This applies power to the d-c motor that closes S_3. Now, contactor K_5 is energized through S_3 and feeds 12 v to the converter, transmitter and modulator.

When S_3 opens at the end of half a revolution of the cam, K_5 removes power from the load and another pulse of current through C_2 opens K_{1B}. Relay K_{1B} stays in this state until the following morning when light again will cause K_4 to close and start the entire cycle.

Operation when an avalanche occurs is similar. If the closed loop forming the trip-wire is broken by an avalanche, the base of Q_1, which was held at ground by the low d-c resistance of the wire now is free to rise. Collector current then flows and K_2 closes and a pulse of current turns on K_5. Power is applied to the motor through R_1 and a contact on K_5. From there on, operation is exactly the same as for the daily test except that R_1 slows the d-c motor giving a much longer trace on the recorder than for the test signal. This difference differentiates between a real avalanche and the daily test transmission.

With slight changes the system could provide flood warnings.

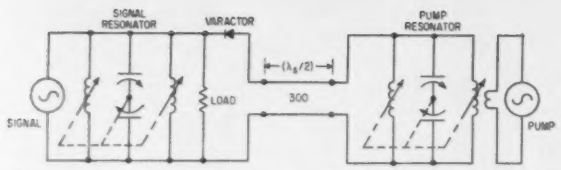

FIG. 1—Degenerate parametric amplifier using butterfly resonators

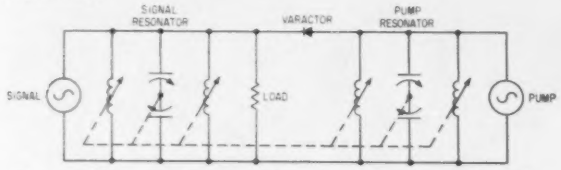

FIG. 3—Suggested circuit for single-knob tuning of a parametric amplifier

FIG. 2—Butterfly resonators are mounted in compartments. Signal resonator, right, has balun attached

Degenerate Parametric Amplifier

USES BUTTERFLY RESONATORS

Design suggests the possibility of ultrahigh frequency parametric amplifiers using low-cost components and continuously tunable with a single control

By RICHARD J. MAYER
Electrophysics Group
The Boeing Co., Renton, Wash.

PARAMETRIC AMPLIFIERS, while offering low-noise operation at ultrahigh frequencies, are relatively complex and usually difficult to tune. A design that shows promise of simplifying construction and tuning is built around two butterfly resonators. Other components in the circuit of this degenerate parametric amplifier (Fig. 1.) include an MA450E varactor diode and a half-wave (at signal frequency) section of 300-ohm twin-lead. A degenerate parametric amplifier is one in which the idler frequency is equal to the signal frequency.

Tuning range of the signal resonator is 135 to 485 Mc, and that of the pump resonator is 300 to 1,000 Mc. The varactor and the signal resonator are connected in series to one end of the twin lead, and the pump resonator to the other. The pump signal is loop-coupled to the pump resonator, and the signal source and load are both direct-coupled to the signal resonator.

Operating at a signal frequency of 485 Mc and a pump frequency of approximately 970 Mc, the amplifier power gain is 18 db at a bandwidth of 10 Mc.

The amplifier is built into the tuning unit chassis shown in Fig. 2. At the left is the pump resonator with the coupling loop for the pump signal. The signal resonator and the varactor are on the right. A balun makes the transition from the unbalanced (coaxial) signal and load lines to the signal resonator.

Twin-lead was used because the resonators were fixed in the chassis and, therefore, both resonators could not be directly connected across the varactor. Because the twin-lead is one-half wavelength long at the signal frequency (and a full wavelength long at the pump frequency), it effectively couples the signal resonator directly across the series combination of the varactor and the pump resonator. (Load impedance of a transmission line is repeated at half-wave intervals.)

Pump and signal circuits do not interact when the resonators are tuned to their respective resonant frequencies because the Q of butterfly resonators is high (typical values of Q range from 200 to 1000); the pump resonator is virtually a short-circuit at the signal frequency and, likewise, the signal resonator is a virtual short-circuit at the pump frequency.

If the resonators were removed from the chassis, it would be possible to eliminate the twin-lead. This suggests the use of gang-tuned resonators that are designed so that one maintains twice the resonant frequency of the other over a frequency band of interest; thus, a parametric amplifier that is tunable over a frequency band with a single control (Fig. 3) appears feasible.

This semiconductor network data processor was developed by Texas Instruments Incorporated under the direction of Manufacturing and Electronic Technologies Laboratories, Aeronautical Systems Division, Dayton, Ohio.

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Fan-Out (TI SN 511, 513)	20
Propagation Delay	75 to 450 nsec
Power Supply	3 to 6 volts
Temperature Range	−55° to +125°C

UNIT	TI SN 510	TI SN 511	TI SN 512	TI SN 513	TI SN 514	TI SN 515
FUNCTION	Flip Flop, Counter	Flip Flop with emitter follower output	NOR/NAND Gate (6 input)	NOR/NAND Gate (6 input) with emitter follower output	Two NOR/NAND Gates (3 inputs each)	Exclusive OR
	Clock pulse is internally capacitive-coupled					

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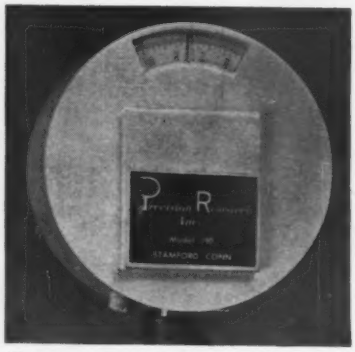
Pressure Data System Uses Digital Transducers

By E. L. KARLSON,
President
Precision Research Inc.,
Stamford, Conn.

DIGITAL data handling system has been designed around a transducer that reads pressure photoelectrically from binary encoded disks. No electrical analogs are involved, which eliminates the need for closely regulated power supplies to obtain highly accurate data. The same patented readout technique will also be used in temperature-monitoring transducers.

Flexibility is one of the basic advantages of a digital pressure data system using the transducers. The transducers can accommodate partial conversion of a plant to automatic operation. The system can later be made fully automatic without replacing the elements that have already been installed.

For example, existing gages can be replaced with the transducers shown in the photograph, which provide local readout of pressure. The same transducers can provide pressure information in either decimal or binary form for remote readout without the added cost and complexity of analog-to-digital conversion. Finally, the pressure data can be fed to a digital control computer for automatic operation.



Pressure transducer provides local indication as well as digital output for remote readout and control

Standard Bourdon tubes are used as the pressure-sensing elements, and they govern accuracy of the pressure data. Consequently, costly high-accuracy instrumentation is unnecessary, which is particularly significant when other system parameters cannot be provided with comparable precision.

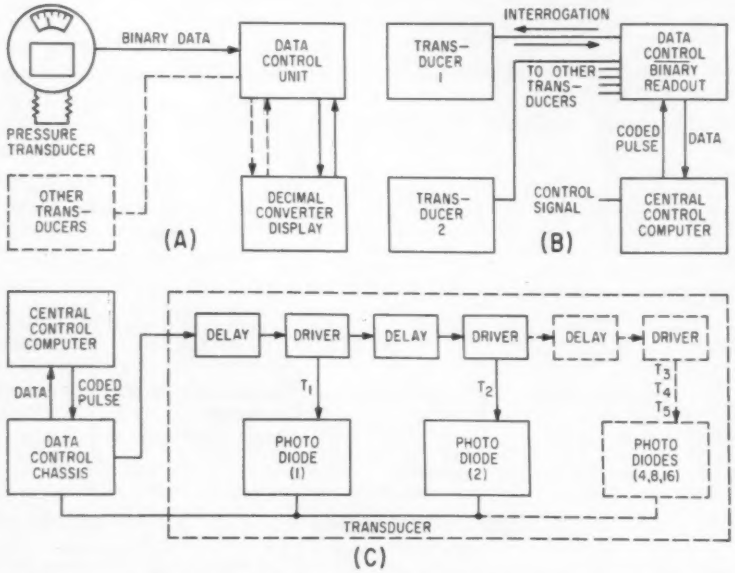
Pressure is read photoelectrically from high-tensile strength nickel disks attached to the pressure-sensing movement. The disks are encoded with gray binary code by precision electroforming. A window in the front face of the transducers permits pressure to be read locally.

A digital pressure data system can include a data control unit and a decimal converter display unit. The data control unit at A in the figure furnishes power for operating as many as six transducers.

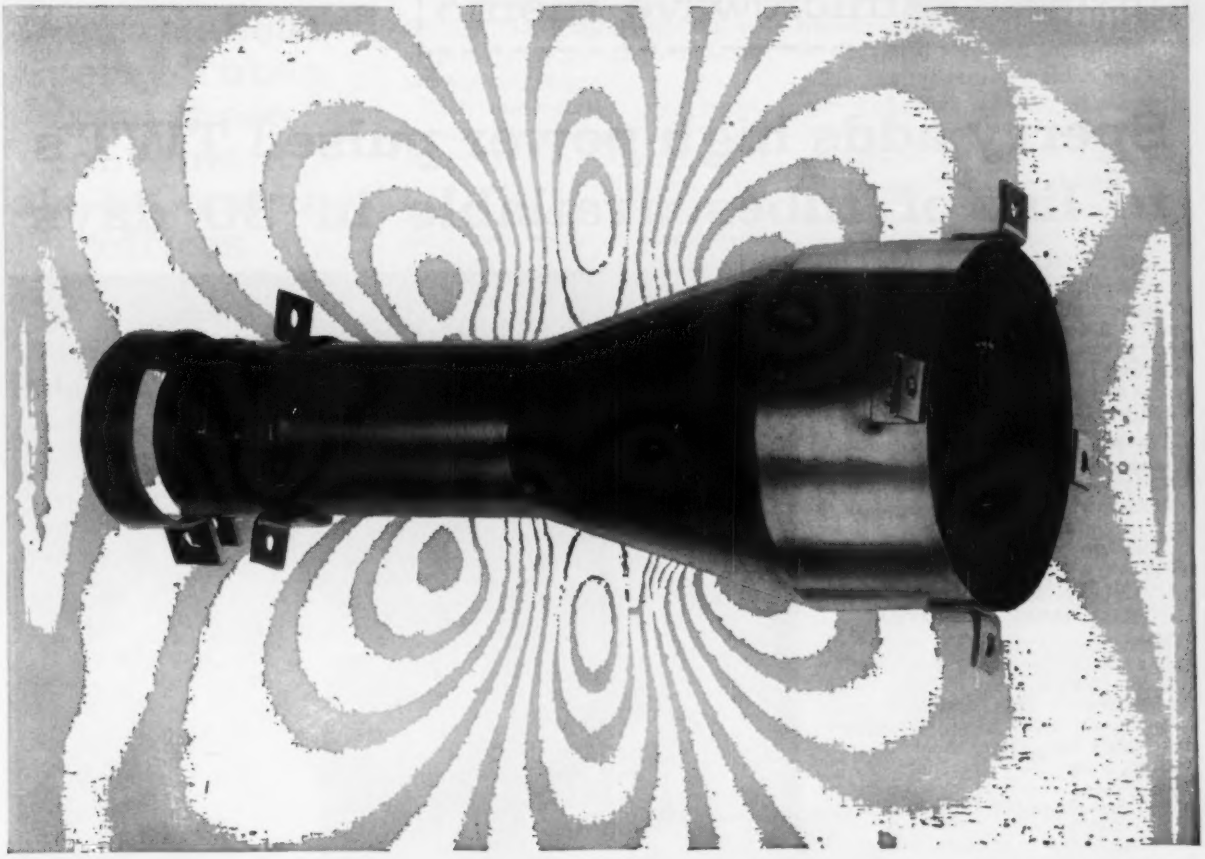
Other system functions performed by the data control unit includes providing binary data continuously on indicator lamps for remote readout of the six transducers. The control unit also feeds the digital information to the decimal converter for display on counters, supplies interrogation pulses for independent binary or decimal readout of transducers and accepts external interrogation pulses from a computer to read out any one of the six transducers. The binary encoded outputs from the data control unit are provided in the form of positive or negative 10-volt pulses.

Information provided to the decimal converter readout display at rates from 1 to 10 bits per second is converted to decimal form and displayed by edge-lighted numerals from .000 to 999. The display can retain the most recent information until the converter is manually interrogated. Six converters fit on a 6 by 9 inch standard rack.

When the system includes a central computer as at B in the figure, any one of the six transducers can be interrogated, and the dated information is fed back sequentially to the computer. To interrogate a particular transducer, the computer feeds an encoded pulse that identifies the transducer to the local data control chassis over a two-wire line. The pulse is interpreted by the con-



Pressure is displayed in binary and decimal form (A), and transducers can be interrogated by computer (B). Driver pulses (C) each read one bit from the associated photo diode



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SPERRY ELECTRONIC TUBE DIVISION microwave memo

Sperry adds high-power pulsed TWT's to list of tubes available in 30 days

In a move to simplify design problems in present and future radar systems, Sperry Electronic Tube Division of Sperry Rand Corporation has added two high-power pulsed traveling wave tubes to the list of advanced microwave tubes available in 30 days.

The two tubes covered by the announcement—the STL-114 and the STC-152—operate in L and C bands, respectively. They are typical of a line of pulsed TWT's ranging from P through V bands which Sperry offers on a firm delivery date basis.

EASY RADAR APPLICATION

Sperry's pulsed TWT's are admirably suited to the demands of application in phased array radars, height finders, search, ECM, and other radar applications. Widely varied in-system experience has proved that their reliability, long life, high power, high gain, and extreme broadband operation make them ideal for radar use.

Design features of this tube family minimize the necessity for system adjustments in the field. Among these features are broadband response, constant voltage operation, and short circuit stability.

VERIFIED RELIABILITY

These pulsed TWT's, produced at Sperry's Great Neck, N. Y., facility, have compiled an impressive record of in-system experience. Such experience has proved that their resistance to shock and vibration damage, their inherent indifference to ambient conditions, and their mounting flexibility make them ideal for ground or airborne application.

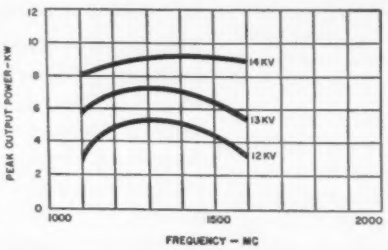
Place your order with your Cain & Company representative. His phone number appears in the adjacent column. Tubes are available within 30 days after receipt of order.

FREE TECHNICAL INFORMATION on the Sperry line of high-power pulsed traveling wave tubes may be obtained by writing to Sec. 102, Sperry Electronic Tube Division, Gainesville, Florida.

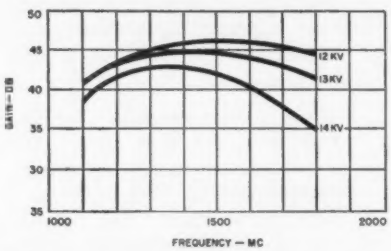
V BAND CAPABILITY

Among Sperry's other interesting activities in pulsed TWT's is the extension of capability into the V Band —26.5 to 40.0 kMc. Although these efforts are largely classified, inquiries are invited from those who have the necessary clearance and need to know.

FACTORY ALIGNMENT of a Sperry TWT within its focusing solenoid greatly simplifies field maintenance. Once this operation has been performed by a skilled Sperry technician, the assembly is self-aligning.



Typical saturated power output vs. frequency for a pulsed Sperry TWT.



Typical small signal gain vs. frequency for a pulsed Sperry TWT.

SPERRY ELECTRONIC TUBE DIVISION
GAINESVILLE, FLA. / GREAT NECK, N. Y.
SPERRY RAND CORPORATION

trol unit, which then sends the approprite interrogation pulse to the selected transducer.

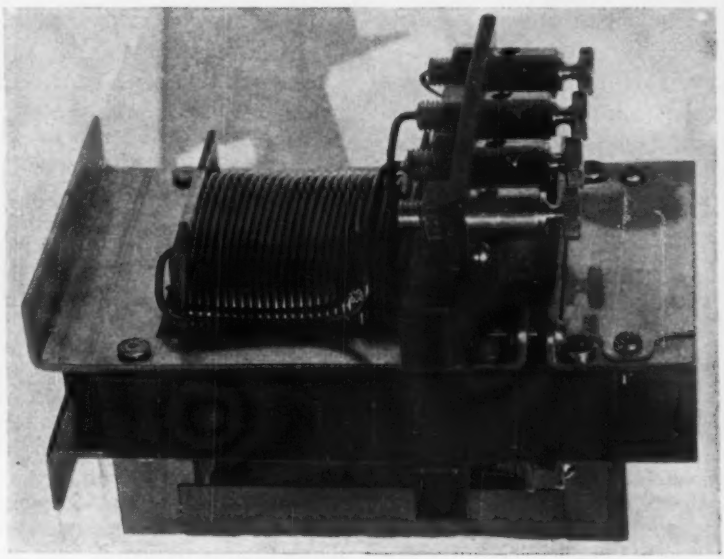
The interrogation pulse passes through the magnetic-core timer at C. The timer, which is inside the transducer, is comprised of the magnetic cores, a series of transistor drivers for the cores and delay networks. Each of the successively more delayed driver pulses reads out one bit by interrogating the associated photo diode. The bits form the serial readout of pressure, which is fed back to the data control chassis. Finally the digital data is fed back to the computer over the same two-wire line.

Zeroing and calibration of the transducers involves adjustment of only a single screw at the rear.

The digital pressure transducers can withstand adverse environmental conditions, such as corrosive atmospheres or outdoor use. No failures occurred in shock tests up to 5 g's, and the transducers can provide remote pressure readout operating over a temperature range from −40 to 250 F. The pressure instruments are being produced with pressure ranges from 10 inches of water full scale to 5,000 psi.

The temperature - monitoring transducers using this readout technique will cover temperature ranges up to 500 F.

Magnetoresistance Voltage Regulator



INDIUM antimonide semiconductor is used to maintain constant output voltage in a regulator designed specifically for tunnel diodes. The regulator is a practical application of the phenomenon of magnetoresistance, in which resistance of a semiconductor varies in proportion to the strength of an applied magnetic field. The magnetoresistance voltage regulator was developed by Battelle Memorial Institute in a research program sponsored by the Aeronautical Systems Center, Air Force Systems Command.

As input to the electromagnet shown in the photograph is increased, it produces a stronger magnetic field. The resistance of the indium antimonide semiconductor located in the field is therefore also increased. Similarly, a decrease in input to the magnet coil decreases magnetic field strength, thereby decreasing resistance.

The regulator can maintain an output voltage of 0.15 volt within ±5 percent at 0.1 amp. This regulation is maintained with changes in load resistance of 50 percent and simultaneous changes of 10 percent in input voltage, normally 1.5 volts.

Much more precise regulation can be achieved with a magnetoresistance regulator when it is used with output voltages of one volt or more.

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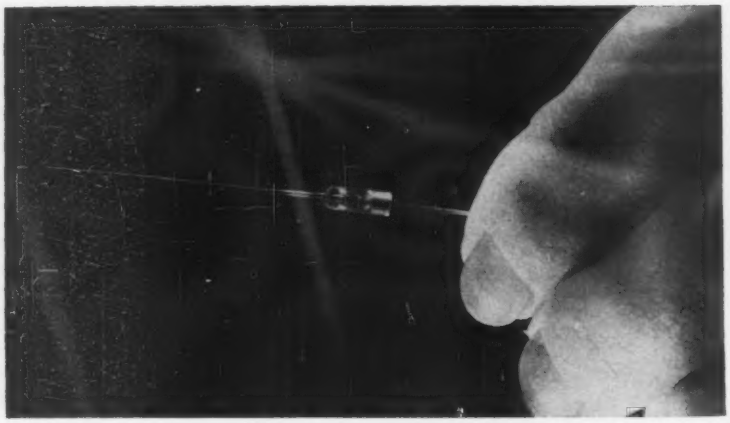
SPERRY ELECTRONIC TUBE DIVISION
SPERRY RAND CORPORATION

CIRCLE 79 ON READER SERVICE CARD

Light-Triggered Device Switches High Power



Controlled rectifier with a light gate turn on handles 160 watts continuously, can eliminate several stages of circuit work

SUBMINIATURE PNPN SWITCHES, recently shown by GE's Rectifier Component Dept. to about 25 engineers in various electronic companies, made the engineers wonder why they hadn't thought of the idea themselves. Most intriguing was the device's high power handling ability—160 watts for continuous operation, two kilowatts for one cycle—which provide wide static switching applications.

Operating principle is based on triggering a *pnpn* junction by light, an effect long known to semiconductor researchers. This phenomenon completely isolates the input from the device, a highly desirable characteristic in a static switch. Also, the user can easily observe the status of the input signal.

Like other photovoltaic devices, this switch responds to light in the 0.4 to 1.1 millimicron region and peaks at approximately 0.8 millimicrons. This generally covers the range of human visibility and up to the near infra red area.

Turn-off turn-on time is being evaluated now, but switching speed is in the microsecond range, comparable to similar silicon controlled rectifiers. Reliability of light source should complement that offered by these semiconductor switches, which are inherently very high. Inexpensive miniature lamps of both incandescent and neon types are available in both life and reliability categories to meet a wide variety of requirements.

Device will respond to light falling at angles perpendicular to the radial axis of the unit. Greatest sensitivity to light is for angles of approximately 45 deg. Optical performance can be enhanced by cylindrical or parabolic reflectors.

Peak reverse voltage and forward breakover voltage ratings vary from 50 volts to over 400 volts. Peak one cycle surge current rating is five amperes. At 35 C, the device is rated up to 400 milliamperes.

Preliminary application notes, supplied by GE, indicate interesting applications as relays, card and tape reading character recognition, photoelectric control and simple switching schemes.

Among computer men, the devices have aroused great interest in card and tape reading and character recognition. Fast, bistable operation presents very sharp wave fronts which simplify circuits and often enhance the operation of following computer circuits. The ZJ235 is a true *on-off* switch in comparison to photodiodes or other semiconductor devices. For character recognition a typical system would consist of an array of light activated switches, light admitted through the cathode end.

One of the most difficult areas for the devices is in detection of objects interrupting a light beam, as great light sensitivity is needed for long light throws, and often circuits should be closed on the absence of light. These obstacles can be overcome by use of an inexpensive lens system, a stronger light source, or both. And to invert the action (closing when light is interrupted) an inexpensive relay can be added, or another silicon controlled rectifier can be included.

These light activated switches can be considered as silent, hermetically sealed relays that can operate as half wave static devices, full wave a-c load, or full wave d-c inductive load. When the light source is energized, the device latches into conduction. On a d-c circuit this latching action results in a simple, inexpensive memory. The device will remain *on* until intentionally turned *off* by methods used with conventional silicon controlled rectifiers, that is, mechanical interruption of the main load carrying circuit or commutation with capacitors.

In an a-c circuit, the device will turn *off* at the end of each positive half cycle. A full-wave bridge configuration is often the most practical circuit when the load demands full wave conduction.

In alarm circuits, light activated switches can accept different signals, a-c or d-c, of any voltage that can energize a lamp. This is usually difficult to accomplish with other types of alarm circuits. The load current limit of 400 ma for normal operation can be exceeded, as it would not be necessary to reblock forward voltage in a manually reset alarm system. The inherent memory of the device locks up the alarm signal, if this is desired.

By using two switches in a back-to-back configuration, efficient power reduction can be obtained in the form of a three-position switch. Power to the load can be reduced to half by illuminating just one of

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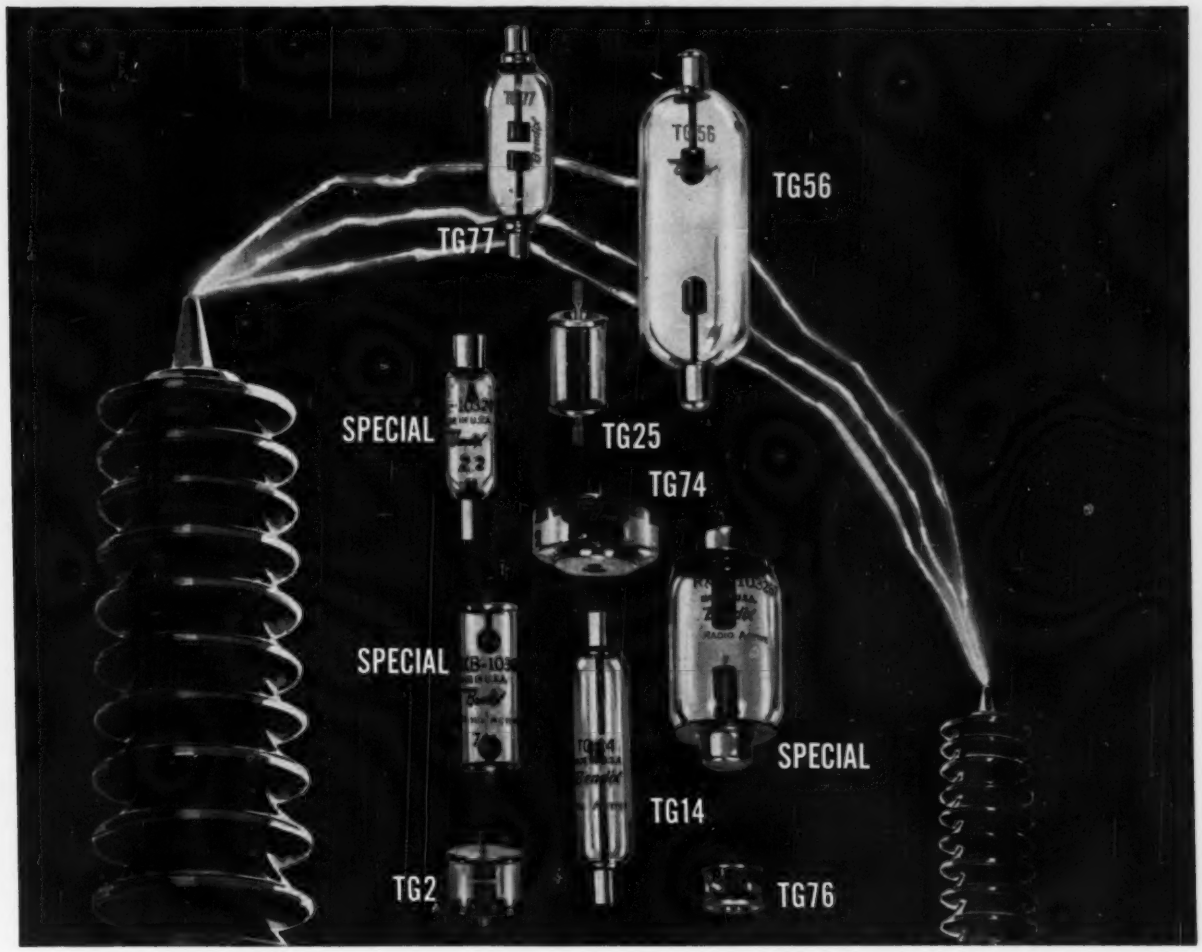

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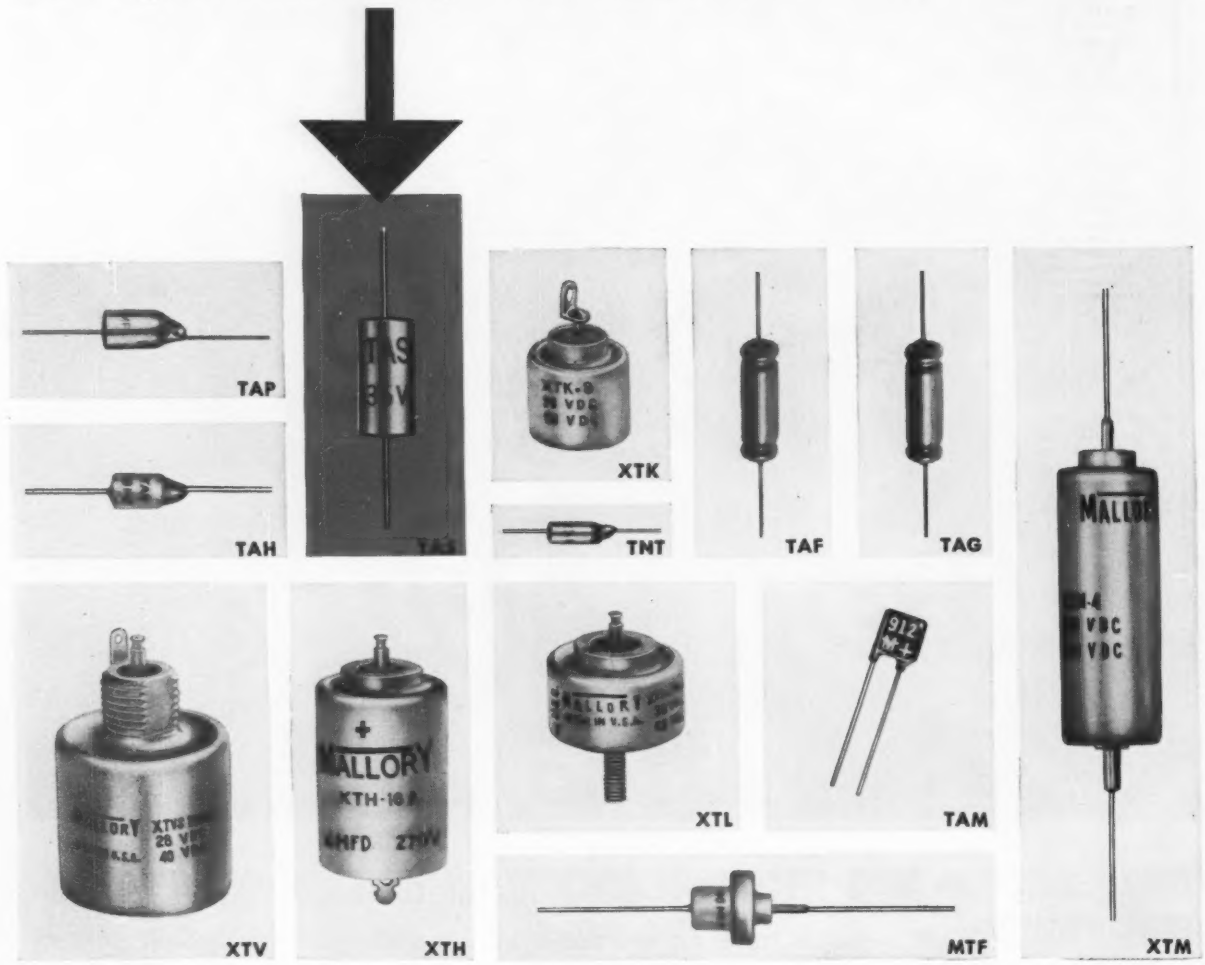

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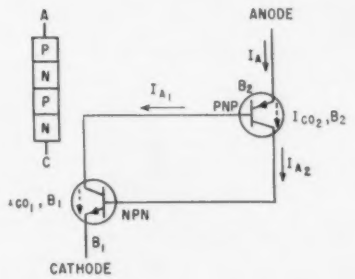
the switches, or full power can be obtained by illuminating both units. Simple power programming can be arranged by turning on one switch, with the other being turned on by a lamp in parallel with the load.

Another suggested application for the light activated switches is for small signal actuation by meter deflection. The light switch offers one of the simplest methods of closing a 400 volt 160 watt contact at the desired position of a meter pointer or disc.

Other suggested applications include simple computer logic, readout from optical-electronic circuits, flame detection, squib firing, light flip-flops, light choppers, and tower light monitors.

To best understand the operation of a *pnpn* switch, such as the ZJ235, Dennis Grapfam, applications engineer at GE, outlined the theory.

It is convenient to visualize the device as consisting of two independent silicon transistors, an *npn* and a *pnp* connected as shown:



The collector of the lower *npn* transistor drives the base of the upper *pnp* transistor, while the *pnp*'s collector drives the *npn*'s base. This positive feedback loop has an overall gain of $(B_1 \times B_2)$, where B_1 and B_2 are the common-emitter current gains of the two transistors.

With no light applied, total anode current, I_A, may be expressed in terms of the two betas and the transistor leakage currents I_{co1}, I_{co2} where,

$$I_{A_1} = I_{CO_1}(1 + B_1) + B_1 I_{A_2}$$
$$I_{A_2} = I_{CO_2}(1 + B_2) + B_2 I_{A_1}$$
$$I_A = (I_{A_1} + I_{A_2})$$

Solving these equations for I_A gives,

$$I_A = \frac{(I_{CO_1} + I_{CO_2})(1 + B_1)(1 + B_2)}{1 - B_1 B_2} \qquad (1)$$

At junction temperatures below rated maximum, and with applied anode voltage less than the device's specified forward breakover voltage, the product $(B_1 \times B_2)$ is less than unity. Since leakage current I_{co} of a silicon transistor can be made very low, total device anode current I_A is also very low (equation 1), and the ZJ235 is said to be in its high impedance or off state.

To initiate the characteristic *pnpn* switching action, i.e. the change-over from high to a low impedance or on state, this same loop gain $(B_1 \times B_2)$ must be raised to unity. From equation 1, I_A goes to ∞ when $(B_1 \times B_2)$ goes to 1, and under these conditions both transistors are driven to saturation. Anode-cathode voltage falls, and device current is limited only by the external source impedance. Because the system is regenerative, the ZJ235 can only be returned to its high impedance state by interruption of the external anode supply.

In practice, the product $(B_1 \times B_2)$ is raised to its initial value by utilizing the collector-current dependence of beta (in a transistor, beta increases with increasing collector current). By driving the ZJ235's anode current above its normal off-state leakage value, $(B_1 \times B_2)$ is effectively raised to unity. This mechanism may be accomplished in any one, or a combination, of three ways:

By raising junction temperature—leakage current and hence beta increases rapidly with rising temperature.

By raising anode voltage—leakage current increases sharply as collector avalanche is approached.

By subjecting the device to incident light—high energy protons, or light particles, entering the silicon lattice releases considerable numbers of hole—electron pairs (compare effect of increasing temperature). These hole-electron pairs add to total anode current, the betas rise, and the light activated device switches. This mechanism is employed in practice.

With light applied to the device, equation 1 becomes modified as follows:

$$I_A = \frac{(I_{CO_1} + I_{CO_2} + I_L)(1 + B_1)(1 + B_2)}{1 - B_1 B_2}$$

where I_L is the current flow due to incident light.

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STRENGTH LEXAN slider for 4-pole switch is 20% glass-filled. The material withstands high impact forces and its flexural modulus is over 1 million psi. Used in rocket sled tests, the filled resin is relatively independent of heat, aging and most environments. It has high melt temperature and excellent electricals. (Atlas Chemical Industries)

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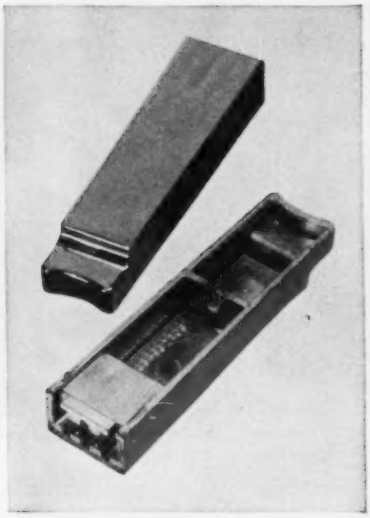

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TRANSPARENCY. Face-glass of this pressure gauge is molded of LEXAN 102 — a new, virtually water-white grade of resin. The instrument uses a gray LEXAN back-plate. Transparent LEXAN resin is shock- and heat-resistant . . . replaces glass. The opaque plastic replaces steel or brass. The two injection molded shells form a strong, good looking case. (United States Gauge)

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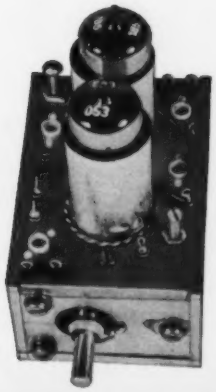

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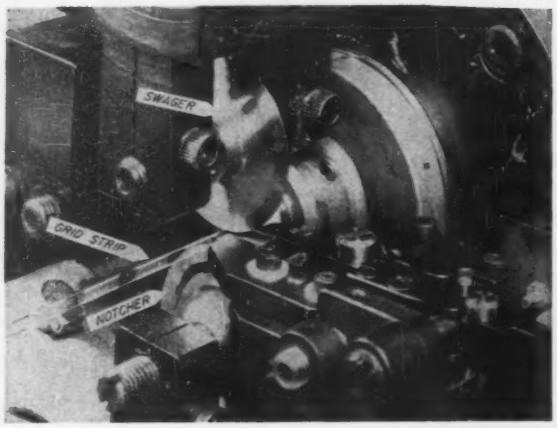
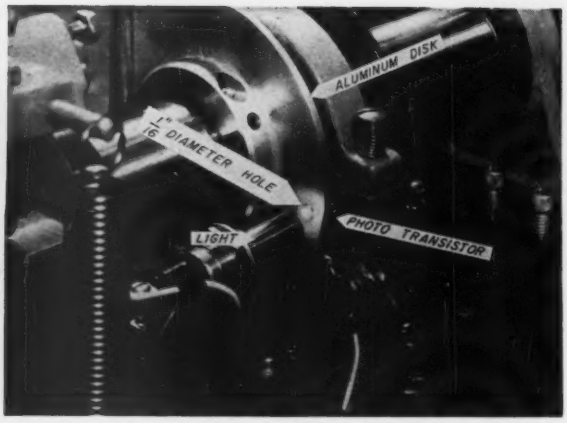


Grid wire is broken automatically at finish of each grid and is picked up at start of next



Control of the wire break mechanism is accomplished with photo transistor and disk on lathe cam shaft

Wire Break Device Cuts Grid Winding Costs

By F. P. EHRHARDT
Western Electric Co.
Allentown, Pa.

TIME AND RAW MATERIAL can be saved in electron tube manufacture by adapting a wire breaking and pick-up mechanism to conventional grid winding machines. Improved grid quality results from reduced handling while operator efficiency is improved. Since the technique requires only a small investment, it can be used in limited quantity production as well as on fully automatic grid winding machines.

Conventional grids are made by attaching small diameter wire in a helix to two larger support wires; the support wires are notched, the grid wire is inserted and the notch is swaged over. The method requires no soldering or brazing and is accomplished with semi-automatic machines. The support wires themselves are pulled from supply spools through grooves in a rotating mandrel; the grid wire is pulled from another spool, as shown in one of the photographs. The swaging wheel peens metal from each side of the notch over the grid wire and locks it in place. Notching and swaging occurs twice for each revolution of the mandrel, since the grid must be attached to both support wires.

The support wires must extend beyond the helical grid at each end for assembly into the tube. In a conventional grid winding machine the notcher and swager wheels are moved out of position by cams when the last turn of one grid is reached and remain that way until the first turn of the next grid is reached. This leaves the lateral wire loose over the grid leg, which is about ¼ of total grid length. After winding, grid strips are cut apart and the excess loose wire on each grid is removed manually and scrapped.

A wire break attachment makes it possible to interrupt the flow of lateral wire during winding so that only the turns required for each grid are wound. Strips of grids are wound as before but without loose turns. After the last turn of a grid is swaged in place, the lateral wire is broken and held until the support wire advances to the next winding position. When a notch is cut in the support wire for the first turn on the next grid in the strip, the wire being held is caught in the notch and swaged in place.

Two carbide jaws provided in the wire break mechanism serve as wire guides as well as a means of pinching the lateral wire being pulled onto the rotating mandrel. A light spring holds the jaws together as wire slides through during winding. As soon as the last required turn of the grid is wound, a solenoid pushes the jaws together, clamping the lateral wire and causing it to break. Timing of the impulse to the solenoid is critical, as is the angular position of the winding mandrel at the time the wire is broken. With precise timing, the lateral wire will break at the last swaged notch and leave a lateral wire tail extending from the carbide jaws long enough to be picked up at the start of the next grid in the strip.

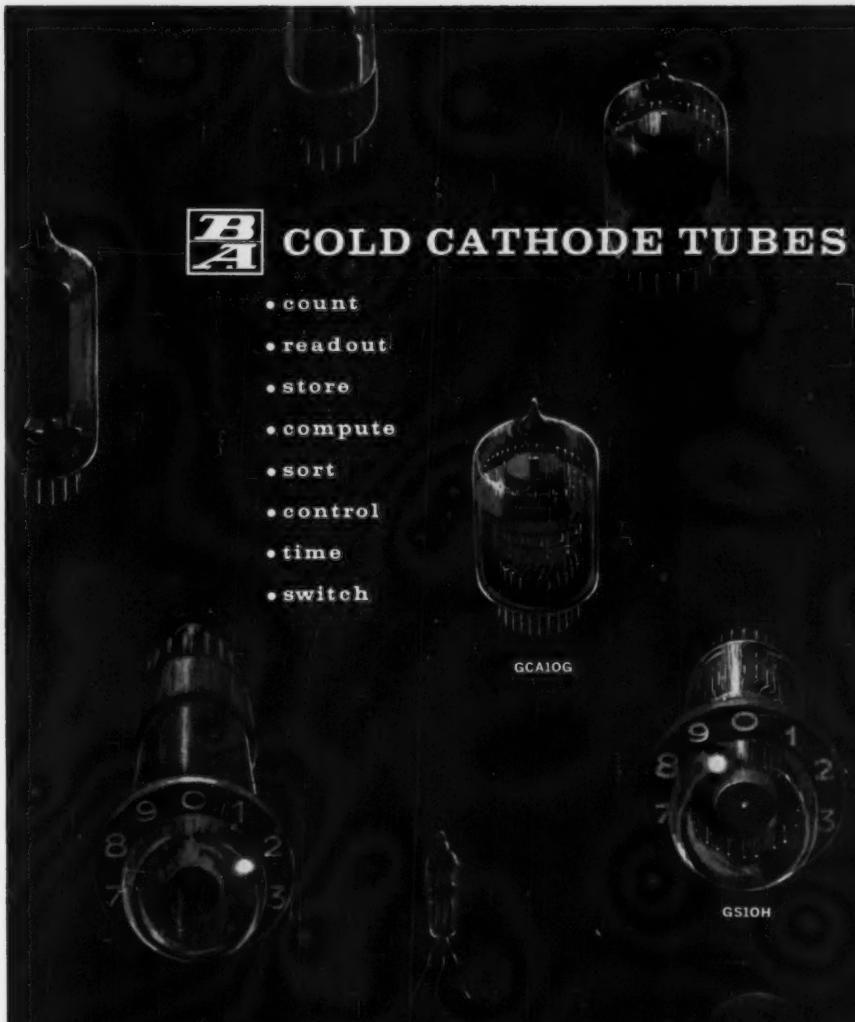
A light source and photo transistor on opposite sides of a disc on the lathe cam shaft allow accurate timing for the breaking mechanism. An important advantage of the attachment is that one operator can attend several machines at the same time, instead of just one.

Vacuum Bakeout Improves Klystrons

THE BROAD BAND KLYSTRON tube on the cover of this issue is Sperry Electronic Tube Division's SAL 166, a high-power, high-energy-per-pulse tube for high power radars now in production at Gt. Neck, N. Y. Operating from 1,215 to 1,365 Mc,

COLD CATHODE TUBES

- count
- readout
- store
- compute
- sort
- control
- time
- switch



TWO NEW TUBES

GCA10G — A recently developed tube for the direct coupling of a readout tube to a Dekatron without the need of any additional amplifiers.

GS10H — New, low cost, miniature selector with access to all cathodes. Seated height — 1 1/32".

Dekatron Tubes — Full line of twelve types for totalizing, sorting, programming or controlling. High speed (up to 20,000 cps). Reliable up to 100,000 hours — low current.

Voltage Reference Tube — Useful in high-level stages of DC amplifiers. No jump in characteristic. Constant internal resistance.

Computer Trigger Tube — Inexpensive subminiature tubes especially designed for computer application. Widely used for slow-speed storage applications.

Tetrode Trigger Tube — Designed for Dekatron coupling, readout circuits and bi-directional counting. Reliable in self-quench circuits. Drift-free operation.

Baird-Atomic has more different types of cold cathode counting tubes than anyone! All have been field proven . . . all feature rugged construction, low power requirements and simple circuitry. And B/A tubes are backed by extensive applications engineering service and a network of distributors in the U. S. and Canada.

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THREE...
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ADDRESS .....
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the tube is believed to have the largest power rating for a 150 Mc bandwidth. Peak power is 12.5 Mw and average power is 60 Kw; gain is 38 db and duty cycle is 0.0061.

The high beam densities used in the tube place severe requirements on the materials used, and also require a hard vacuum during the life of the tube. Metals used in the structural parts of the tube are primarily oxygen-free copper and stainless steel; ceramic instead of glass is used for other parts since it allows bakeout at temperatures near 600 C, instead of the 450 C usual with glass.

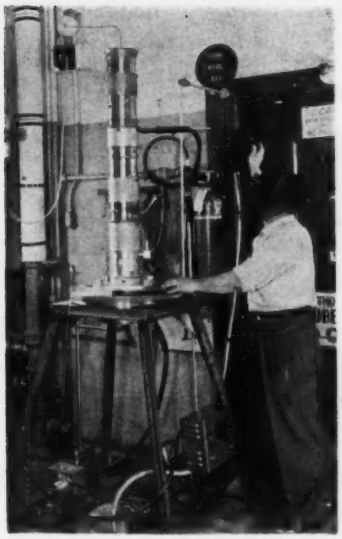
The tube is built up from subassemblies, many of which are vacuum fired at 1,000 to 1,100 C before being assembled into the tube. High temperature vacuum firing is especially important for those internal tube structures that are near the cathode. To maintain high vacuum during service, the number of joints that must be vacuum tight

Optical pyrometer is used to check temperature of subassembly during vacuum firing

are reduced to a minimum by using one-piece hydroformed parts wherever possible. After the major subassemblies have been r-f brazed in hydrogen furnaces, they are heliarc welded together to form the seven foot high, 300 lb. tube.

The assembled tube is evacuated and an ion pump is attached to it to bring the pressure inside the tube down to 10^{-6} or 10^{-7} mm of mercury; the ion pump remains with the tube during the vacuum bakeout that follows and is removed only when the tube is ready for test.

Vacuum bakeout of the assembled



Klystron is Heliarc welded on motor driven turntable

and evacuated tube takes 48 hours. Six hours are required to bring the tube up to approximately 600 C, bakeout takes 30 hours, and 12 hours are required for cooling. Cathode conversion takes place during bakeout, with barium and strontium carbonates giving off CO and CO_2 to release the barium and strontium; the gases are removed by the ion pump, which is still attached to the tube. Although 16 to 20 hours are normally required for cathode conversion, the use of CerAlloy 400, manufactured by Ronson Metals Corp., Newark, New Jersey, cuts the time down to two hours.

Pressure in the final bakeout oven is about 10^{-3} mm of mercury. Vacuum bakeout at this relatively low pressure has two important advantages. First, any leak that develops in a tube does not result in a large influx of gases into the tube to cause oxidation and, usually, tube destruction; no tube bodies have been lost because of leaky seals since the oven has been in use. Second, hydrogen and oxygen diffusion through tube structures (which increases with temperature) is less because the pressure differential across the walls is less. The oven itself is 14 feet high, eight feet of which are under ground.

When the tube is cooled, it is removed from the oven and voltage processed to burn off metal whiskers. After final outgassing to 5×10^{-9} mm of mercury, the tube is pinched off and is ready for tests.

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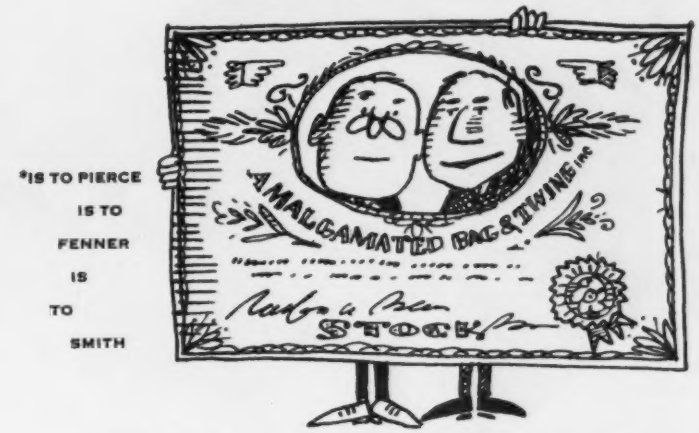

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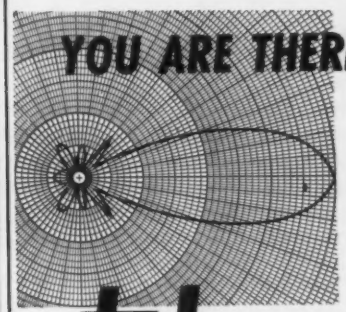

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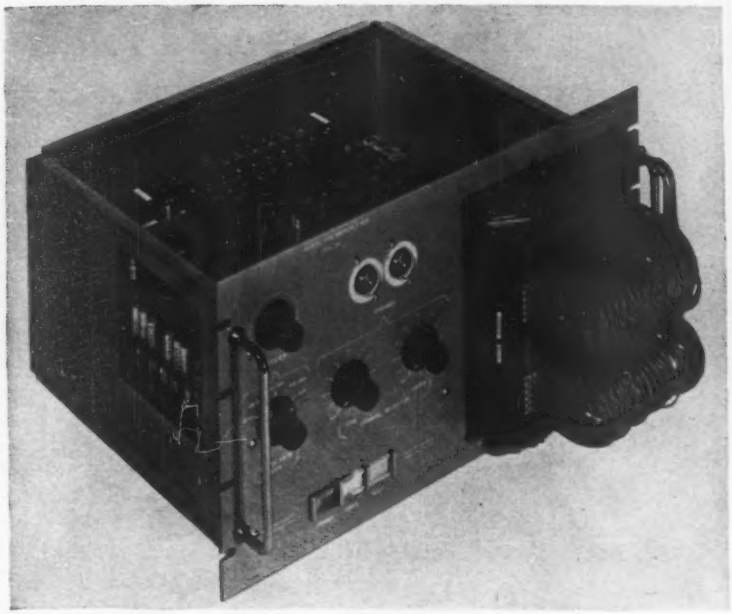
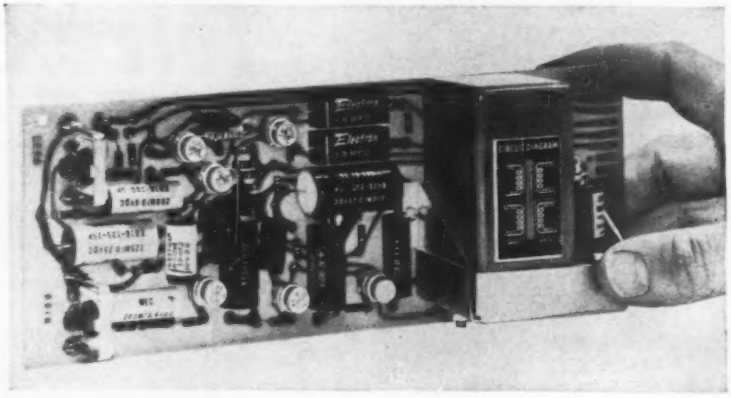


Low & High-Level Multiplexer

FOR GROUND-BASED, GENERAL-PURPOSE USE

STELLARMETRICS, INC., 210 E. Ortega St., Santa Barbara, Calif. Model 100 Microplexer is an all-electronic sampling switch. It offers 100 separate input channels, sequentially switched to a common output bus, on each of the two poles which, in combination, apply the input information to a common output load. Full scale input signal ranges as small as ± 5 mv may be sampled at any rate from 0 to 1,000 cps at 0.1 percent accuracy; and no drift (with time or temperature) can be measured. At the core of the unit is the Magristor which uses liquid as its enabling means, essentially eliminating noise.

CIRCLE 301 ON READER SERVICE CARD



Chopper Stabilizing Amplifier

SHIELDED AND ISOLATED INPUT

C.E.S. ELECTRONIC PRODUCTS, 5026 Newport Ave., San Diego 7, Calif. Series 300 has a full wave transformer, a floating and shielded input system and uses a 10,000-hr mechanical chopper in conjunction with solid-state circuitry to provide an amplifier of high performance. With an input impedance of 100,000 ohms, the amplifier noise is less than 1 μv with a 1.6 cps filter on the output. Gain is 100 db and minimum output is ± 5 v.

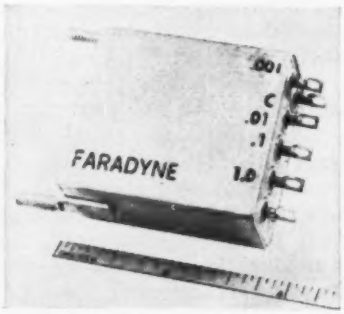
CIRCLE 302 ON READER SERVICE CARD

Variable Delay Line

HIGH RESOLUTION

COMPUTER DEVICES CORP., 6 W. 18th St., Huntington Station, N.N.Y. A delay range from 0 to 150 μsec in precise steps of 0.1 μsec is provided in the model V175. It utilizes an insertion switching technique that gives constant input and output load impedance regardless of the delay setting. Unit provides an output rise time which decreases with delay and at maximum delay is less than 4 percent. Attenuation is 6 db; distortion, less than 3 percent; accuracy at any delay setting, better than 2 percent; impedance, 500 ohms.

CIRCLE 303 ON READER SERVICE CARD

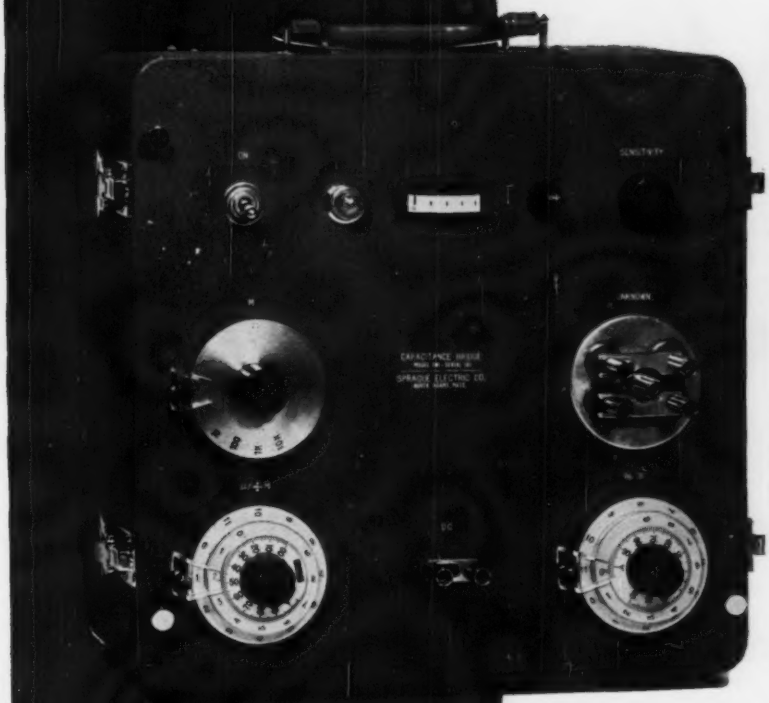


Multiple Capacitor

HERMETICALLY SEALED

GULTON INDUSTRIES, INC., 212 Durham Ave., Metuchen, N.J. Hermetically sealed Faradyne Mylar capacitor has capacitance values of 1 μf, 0.1 μf, 0.01 μf and 0.001 μf within one single unit. Tolerance on these values within one unit is ± 0.25 percent. Use of the unit in oscillo-

Now! For the first time...



TEST ELECTROLYTIC CAPACITORS

Safely... Accurately... Simply!

SPECIFICATIONS

Capacitance
Range: 0 to 120,000μF at 120 cps
Accuracy: ±(1% of reading +10μμF)
Sensitivity: ±(0.1% of reading +10μμF)

Dissipation Factor
Range: 0 to 120% at 120 cps
Accuracy: ±(2% of reading +0.1% DF)
Sensitivity: ±(0.2% of reading +0.05% DF)

Maximum Voltage to Unknown
A-C: 0.5v RMS at 120 cps
D-C: 0-600v (external)

Null Detection
Built-in Galvanometer to Indicate Bridge Balance

Power Input
105-125v, 60 cps, 15w

Case
Sturdy Aluminum Cabinet with Blue Textured Finish, Grey Panel

Dimensions
12" Wide x 12" High x 6" Deep

Note: Five other models, with variations in power inputs and test frequencies, are also available.

■ The Sprague Model 1W1 Capacitance Bridge introduces a new concept in bridge design. Built *by* capacitor engineers *for* capacitor users, it incorporates the best features of bridges used for many years in Sprague laboratories and production facilities.

■ The internal generator of the 1W1 Bridge is a line-driven frequency converter, and detection is obtained from an internal tuned transistor amplifier-null detector, whose sensitivity increases as the balance point is approached. It has provision for 2-terminal, 3-terminal, and 4-terminal measurements, which are essential for accurate measurement of capacitors with medium, low, and high capacitance values, respectively.

■ The Model 1W1 Capacitance Bridge will not cause degradation or failure in capacitors during test, as is the case in many conventional bridges and test circuits. The 120 cycle a-c voltage, applied to capacitors under test from a built-in source, never exceeds 0.5 volt! It is usually unnecessary to apply d-c polarizing voltage to electrolytic capacitors because of this safe, low voltage.

For complete technical data on this precision instrument, write for Engineering Bulletin 90,010 to Technical Literature Section, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

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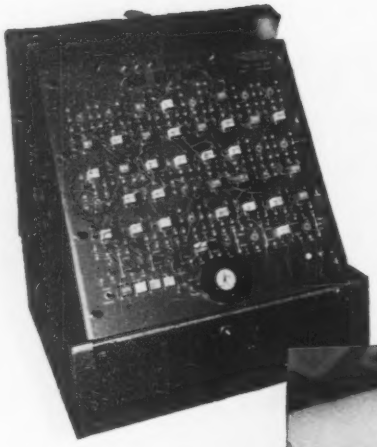
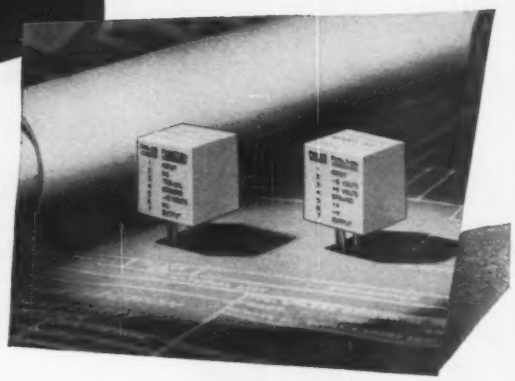


Circuit Designers!



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scopes and other instruments can eliminate the need for employing potentiometers, which are usually required to adjust to the desired RC constant.

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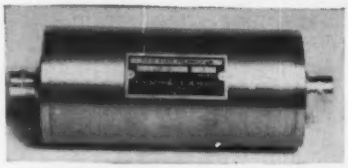

Preamplifier

FOR TELEMETRY USE

VITRO ELECTRONICS, 919 Jesup-Blair Drive, Silver Spring, Md. The Nems-Clarke SSP101 is a low noise solid state preamplifier with a maximum noise figure of 4.5 db, a gain of 25 db minimum, and is flat across the band at 3 db. It is designed for the 225-260 Mc telemetry range. The SSP101 weighs 19 oz, can be used in any environment and is mounted at the antenna or directly at the coax cable.

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Crystal Switch

AMERICAN ELECTRONIC LABORATORIES, INC., Richardson Road, Colmar, Pa. Model SNB152A vhf/uhf crystal switch covers the frequency band from 20 Mc to 1,000 Mc with an insertion loss no higher than 3.5 db.

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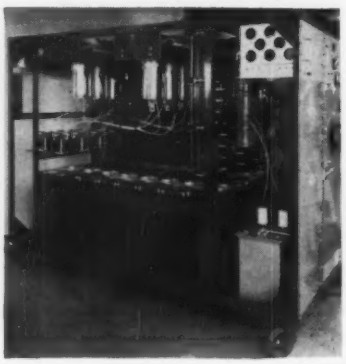

Capacitor Banks

48,000 JOULES

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more usable sensitivity 10 mc to 44,000 mc

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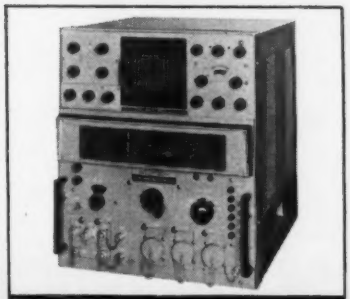

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Band		RF SENSITIVITY*
1.	10 - 420 MC	—100 to—110 dbm
2.	350 - 1000 MC	— 95 to—105 dbm
3.	910 - 2200 MC	—100 to—110 dbm
4.	1980 - 4500 MC	— 90 to—100 dbm
5.	4.5 - 10.88 KMC	— 90 to—100 dbm
6.	10.88 - 18.0 KMC	— 85 to—100 dbm
7.	18.0 - 26.4 KMC	— 70 to— 90 dbm
8.	26.4 - 44.0 KMC	— 60 to— 85 dbm

*Measured when signal and noise equal 2X noise.

Using one tuning head which contains one triode and two Klystron oscillators, Model SPA-4a offers more exclusive advantages for applications demanding extreme sensitivity, stability, versatility, accuracy.

• Exceptionally low distortion. • Highly resolved & calibrated analysis. • Three precisely calibrated amplitude scales —40 db log, 20 db linear, 10 db power. • two independent frequency dispersion ranges—continuously adjustable —0—70 mc and 0—5 mc. Negligible internal frequency modulation permits narrow band analysis of FM problems • Variable I. F. bandwidth from 1 kc to 80 kc • Push-button frequency selector. • Synchroscope output with 40 db grain. • Accurate measurement of small frequency differences. A self-contained marker oscillator, modulated by a calibrated external generator, provides accurate differential marker gips as close as 10 kc.

Tremendous flexibility and many unique advances of Panoramic's compact SPA-4a make it unsurpassed for visually analyzing FM, AM and pulsed signal systems; instabilities of oscillators; noise spectra; detection of parasitics; studies of harmonic outputs; radar systems and other signal sources.

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December 15, 1961

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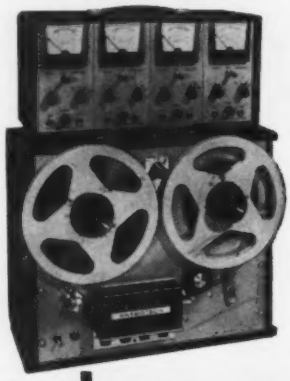

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megamp at 20 Kv in 3 μsec pulses. Charging time is less than 1 minute for each unit. As many as 60 separate banks can be connected in parallel, raising total energy output to 3×10^6 joules. Amperage increases as the square root of the energy, so currents of 2.4×10^7 amp are obtainable from these standard units.

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Tantalum Capacitor

SOLID, POLARIZED

GOOD-ALL ELECTRIC MFG. CO., Ogallala, Neb. Type 901 solid polarized tantalum capacitor features high quality and long, reliable life. Ratings are from 0.0047 to 330 μf and 6 to 35v d-c. Environmental characteristics meet MIL-C-26655A. They come in 4 subminiature case sizes and temperature range is -55 C to $+125$ C. Dissipation factor is 6 percent. Type 901 is suited for transistor, missile, communication, or similar circuitry.

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Voltage Reference

100 DB ISOLATION

CIRCUIT DYNE CORP., 480 Mermaid St., Laguna Beach, Calif. Isolation from line voltage changes in the order of 100 db is a feature of the type PR1 solid-state voltage reference supply. Unit is available in models to accept both 115 v and 6.3 v inputs, from 50 to 400 cps. Outputs may be specified at 5.9, 8.6, 11.0, 14.5, 17.2 and 22.0 v, nominally.

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Harmonic Generator

TELONIC INDUSTRIES, INC., Beach Grove, Ind. Wide-range harmonic generator can produce birdy mark-

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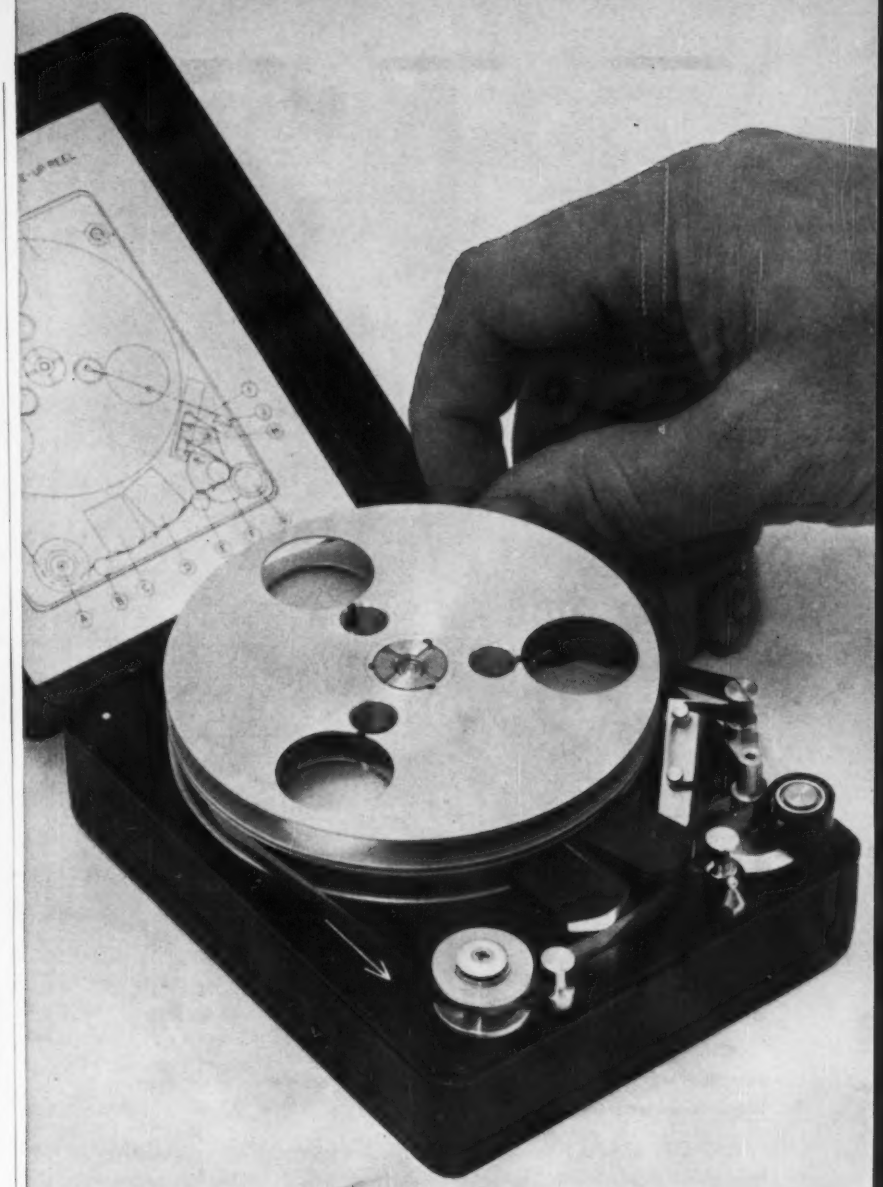

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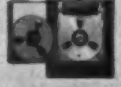

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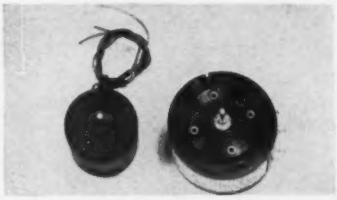

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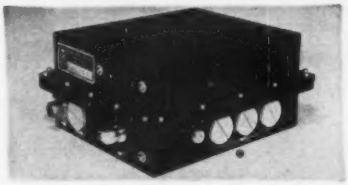

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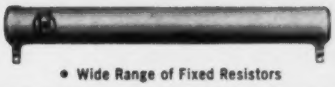

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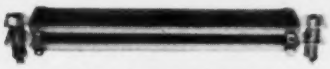

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Other Krohn-Hite amplifiers include the direct-coupled, wide band DCA-10 (10 watts), and DCA-50 (50 watts). *Also, Krohn-Hite Oscillators, Filters and Power Supplies.*

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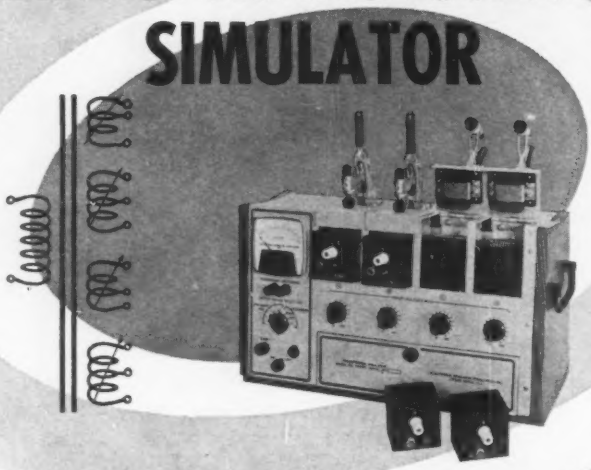
NEW ERA'S TRANSFORMER SIMULATOR



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Four secondaries (values: 10, 100, 400, 1500 VAC) are provided with each instrument, and other values are available as accessories. Both primary and secondary AC voltages may be read with the built-in metering circuit. All coils are center-tapped, and maximum rating per coil is 60 VA. Transformer input is 50-1000 cps, and provision is also made for square-wave or non-sinusoidal primary inputs.

Price: (Complete with 4 secondaries) **$425.00** (F.O.B. plant)

SPECIFICATIONS

Input: 115 VAC nominal, 50-1000 cps
Output Power: 60 VA per secondary, 250 VA total
Secondary Ranges: 11 total, 0-5 VAC to 0-1500 VAC
Regulation per Secondary: 10% for 10-100% load change
Metering: Primary and secondary AC voltages
Meter Range: 0-15 VAC x 1 x 10 x 100
Size: 10" x 17" x 8"
Secondaries may be used in parallel or series
Provision for square wave or non-sinusoidal inputs
Additional Coil Accessories—$15.00 each

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ucts Division, San Fernando, Calif. Type RT-1 variable attenuator has a range of 0 to 60 db to an accuracy of ±2 db over the frequency range of 0 to 3,000 Mc.

CIRCLE 313 ON READER SERVICE CARD

Shaft Position Encoder

MINIATURE UNIT

DATA TECH, 238 Main St., Cambridge 42, Mass. The Vernisyn model VMI 15-216 digital shaft position encoder provides a 16 bit absolute readout of shaft position to an accuracy of ±½ bit in a single turn in a 1½ in. diameter by 2 in. package including electronics. This model provides an output in the form of fine and coarse pulse trains on separate lines such as to provide a complete angular position answer with respect to a reference radius every 10 millisec.

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Decade Counting Unit

SOLID STATE

COMPONENTS CORP., 106 Main St., Denville, N.J. The DCU-100 will count at speeds from d-c to over 200 Kc with a double pulse resolution of less than 3 μsec. Four transistorized binaries with diode steering provide staircase output to drive directly an inexpensive D'Arsonval readout meter. An appropriate carry pulse output will drive another DCU-100 directly, so that a counting chain can easily be assembled. Each DCU-100 requires less than 10 ma at 6 v for operation.

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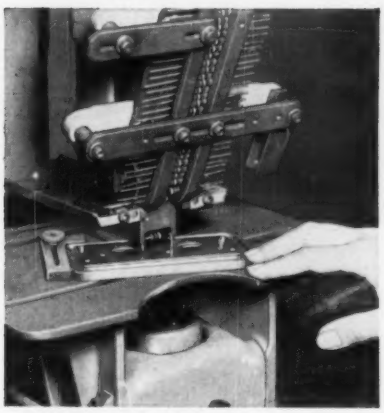

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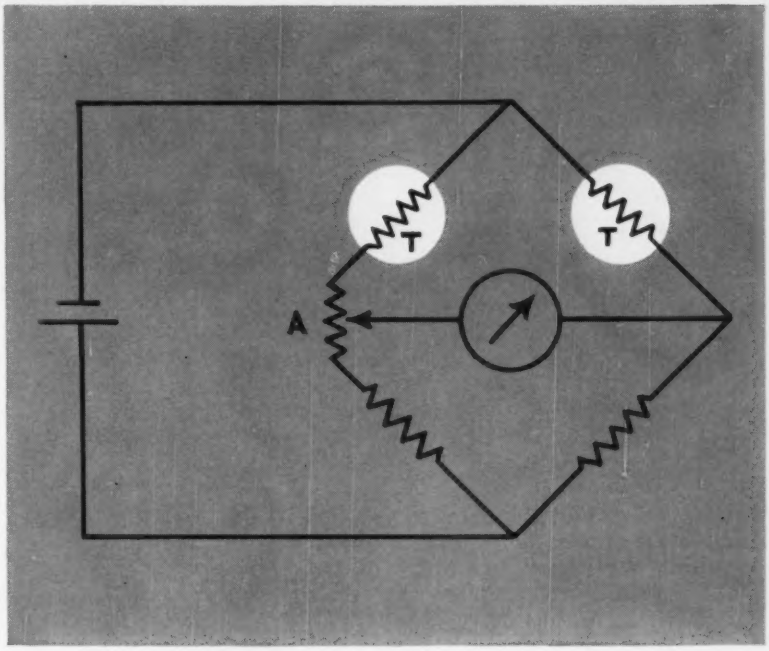
CIRCLE 219 ON READER SERVICE CARD

ONE OF A SERIES EXPLORING **THERMISTOR** APPLICATIONS



A little thermistor makes a big difference in many thermal conductivity instruments

Place two small bead thermistors in a bridge circuit where enough current flows to heat them to 150° C, and you'll find you have an instrument for the measurement of many different physical phenomena. *For example:*

GAS ANALYZER — Place the thermistors in small cavities filled with indentical gases, and balance the bridge by varying the setting of "A". A change in the gas in one of the cavities will either raise or lower the resistance of the thermistor because of a change in the thermal conductivity. This will unbalance the bridge and give a reading on a meter.

FLOW METER — Seal a thermistor in a cavity, and place the other thermistor in a pipe. Balance the bridge when there is no flow through the pipe. When the flow starts, the resistance of the thermistor changes, and the bridge becomes unbalanced.

ANEMOMETER — Design the instrument with a sensing thermistor held in free air, and it will be capable of measuring air velocity from the slightest breeze to a gale.

VACUUM GAUGE — Place one of the thermistors in an evacuated bulb and the other in a chamber connected to a vacuum pump. Pump the chamber down to a high vacuum, and balance the bridge. A reading can be obtained when the chamber is not a high vacuum because the presence of air will cool the thermistor and raise its resistance.

Thermistors can be used in many other circuits to great advantage. For details, application assistance and new Thermistor Catalog EMC 4, write:

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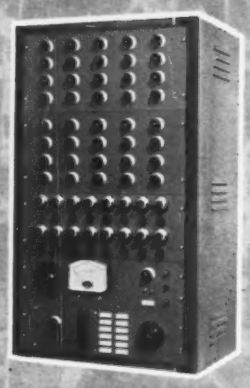
MESUR-MATIC'S GO/NO-GO PRODUCTION LINE TEST EQUIPMENT

The unique Mesur-Matic line of GO/NO-GO test equipment makes it possible to establish inspection tolerances to extremely precise limits and yet utilize non-technical operator personnel. Errors of interpretation are completely eliminated by means of the flashing red and green lights which clearly indicate either a "GO" (within tolerance) or "NO-GO" (out of tolerance) condition. All models are available for either rack or bench mounting.

TRANSFORMER TESTER

The Model TT-1-P56 is designed for precision evaluation of 50 and 60 cycle power transformers in the 1 to 1000 VAC range. Under actual operating conditions, each winding is tested against every other winding and the frame, to pre-established inspection tolerances. The voltage accuracy of each secondary and tap is individually indicated by means of the GO/NO-GO lights. Also available are testers for RF and audio transformers and 400, 800 and 1200 cycle power transformers.



DC COMPARATOR

The Mesur-Matic DC Comparator is designed for use as a "mid-line" comparison unit, making it possible to control test parameters to extremely precise limits without the need for complex, expensive equipment. The unit may be used to monitor flow rates, pressure, AC or DC voltage and current levels, frequency, temperature, humidity or any action which can be measured electrically through the use of transducers.

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The Model IC-1-LMN may be used not only for the precision testing of individual components but also for resistor-capacitor and resistor-inductor networks.

Mesur-Matic makes available still other equipment for a wide range of precision-test applications on the production line and in the lab. Circle the reader service card number below for complete data.

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PRODUCT BRIEFS

SERVO ACTUATOR electro-hydraulic. Western Design & Electronics, Santa Barbara Airport, Goleta, Calif. **(316)**

VERSATILE INK for plated circuits. Naz-Dar Co., 461 Milwaukee, Chicago 10, Ill. **(317)**

TRANSISTOR CIRCUIT-MOUNT offers complete flexibility. Sanders Associates, Inc., 95 Canal St., Nashua, N. H. **(318)**

PULSE TRANSFORMERS subminiature. Valor Instruments, Inc., 13214 Crenshaw, Gardena, Calif. **(319)**

SINGLE CRYSTALS ammonium dihydrogen phosphate. Electro-Ceramics, Inc., 2645 South 2nd W., Salt Lake City 15, Utah. **(320)**

DYNAMIC ANALYZER analog recording. Digital Dynamics, Inc., 4201 Redwood Ave., Los Angeles 66, Calif. **(321)**

SCREEN PRINTING CHASE controlled stretch. Kay-Ess, Inc., 8 North St., Danbury, Conn. **(322)**

D-C INTEGRATING SERVO high stability. Kearfott Division, General Precision, Inc., 1150 McBride Ave., Little Falls, N.J. **(323)**

INSTRUMENTATION CART 16 in. wide, 32 in. high, 32 in. long. Atlantis Metal Products Division, P.O. Box 451, Garland, Texas. **(324)**

INDICATOR TUBE operates off transistors. Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L.I., N.Y. **(325)**

DIGITAL RECORDER multichannel. Bytrex Corp., 50 Hunt St., Newton, Mass. **(326)**

CRYSTAL DETECTOR operates from 1 to 12.4 Gc. Alfred Electronics, 3176 Porter Dr., Palo Alto, Calif. **(327)**

PHOTOMULTIPLIER ¾-inch. Westinghouse Electronic Tube Division, Elmira, N.Y. **(328)**

UHF TV TRANSLATOR 20-watt unit. Adler Electronics Inc., One LeFevre Lane, New Rochelle, N.Y. **(329)**

MICROMINIATURE POT 0.03 oz. Miniature Electronic Components Corp., Holbrook, Mass. **(330)**

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EXPERIMENTAL RESEARCH

Measurements and analysis of ICBM flight phenomena for discrimination and for decoy design purposes, including optical, aerodynamic and RF effects.

SYSTEM ANALYSIS

Studies to apply research findings to advance the technology of ICBM and AICBM systems.

INSTRUMENTATION ENGINEERING

Designing radar, optical and telemetry equipment with which to measure ICBM flight effects under actual range conditions.

RADAR SYSTEMS RESEARCH

Extending the theory and application of radar techniques to problems of discrimination, countermeasures and performance in a dense-target environment.

HYPERSONIC AERODYNAMICS

Study of the flow-fields around re-entering bodies for various body designs and flight conditions. Excellent computer facilities available.

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Theoretical and experimental studies in radar back-scattering. Interaction of RF radiation with plasmas.

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Literature of the Week

POWER SUPPLY Deltron Inc., 4th & Cambria Sts., Philadelphia 33, Pa. Bulletin DP 2026A gives a detailed description of the DIPAC dissipationless power amplitude control power supply. **(331)**

R-F FILTERS Genistron, Inc., 6320 W. Arizona Circle, Los Angeles 45, Calif., has released the 52-page catalog F-101 on a line of standard radio interference filters. **(332)**

EPOXY CASTING RESIN Emerson & Cuming, Inc., Canton, Mass. Preliminary technical bulletin covers Stycast 1264, a transparent high impact epoxy casting resin. **(333)**

MICROWAVE FILTERS Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, Calif. A technical bulletin illustrates and describes the WJ-501 electronically-tuned microwave filters. **(334)**

COMPONENT END SEALING Epoxy Products Division, Joseph Waldman & Sons, 137 Coit St., Irvington 11, N.J. An information bulletin tells how to end seal electronic components for environmental protection. **(335)**

THERMOCOUPLE SELECTOR BOARD Smith Thermotronics, Inc., Conshohocken, Pa. TSB-1, a wall mounting sample board, provides quick selection of thermocouples. **(336)**

TRANSISTORIZED RELAY General Electric Co., Schenectady 5, N. Y. Bulletin GPC-B49 describes the CR120F transistorized sensitive relay. **(337)**

ASSEMBLIES & HARNESSES Microdot Inc., 220 Pasadena Ave., South Pasadena, Calif. Assemblies and harnesses for miniaturized coaxial circuitry are described in bulletin A&H-1. **(338)**

NON-ENVIRONMENTAL CONNECTORS Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. Features of the series 610, 710, and 810 tiny non-environmental connectors are described in a 10-page bulletin. **(339)**

AUDIO-VISUAL PRESENTATION AVDOC, a division of Conductor-lab, Inc., Groton, Mass., announces

a 4-page brochure on its capabilities and the availability of its service in the area of audio-visual presentation. **(340)**

SUBMINIATURIZATION Tri-Lab Electronics, Inc., 4319 Twain Ave., San Diego 20, Calif. A brochure on subminiaturization products and services is available. **(341)**

H-V RECTIFIER ASSEMBLIES Micro-Semiconductor Corp., 11250 Playa Court, Culver City, Calif. Bulletin 106 describes a line of high voltage rectifier assemblies. **(342)**

INSTRUMENTATION Empire Devices Inc., Amsterdam, N.Y. Catalog 614 presents the company's standard equipment including noise and field intensity meters, instruments for microwave systems & components, radar interference blankers. **(343)**

ANALYZING INSTRUMENTS Allison Laboratories, Inc., 11301 Ocean Ave., LaHabra, Calif. Catalog 860 illustrates and describes a line of analyzing instruments including model 201 variable filter. **(344)**

H-V SOURCES Smith-Florence Inc., 4228 Twenty-Third Ave., West, Seattle 99, Wash. A 4-page folder illustrates and describes a line of d-c regulated power sources from 0 to 20,000 v. **(345)**

AUTOMATIC DIRECTION FINDER Marconi's Wireless Telegraph Co. Ltd., Marconi House, Chelmsford, England. Bulletin TD271 deals with the model AD 360 fully transistorized automatic direction finder. **(346)**

RELAY TESTER Electronic Engineering Co. of California, 1601 E. Chestnut Ave., Santa Ana, Calif. Catalog sheet contains features and specifications of model RT-905 relay tester. **(347)**

VHF PREAMPLIFIERS Community Engineering Corp., State College, Pa. Bulletin covers a line of vhf ultra-low-noise preamplifiers. **(348)**

SHIFT REGISTERS Epsco-Components, 275 Massachusetts Ave., Cambridge 39, Mass., offers a 4-page brochure on a line of standard magnetic shift registers. **(349)**

TANTALUM CAPACITORS Ohmite Mfg. Co., 3695 Howard St., Skokie, Ill. Cross-reference lists, in alphanumerical order, the wet-electrolytic slug and foil tantalum capacitors of other manufacturers along with Ohmite equivalents. **(350)**

Optimum phase lock tracking!

—Just one reason you can't beat DCS Discriminators!

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The DCS family of discriminators offers the widest frequency ranges available. Discriminators to accommodate subcarriers in excess of 1 mc, intelligence frequencies in excess of 100 kc, constant-bandwidth, frequency translation, and predetection signals are standard, off-the-shelf products.

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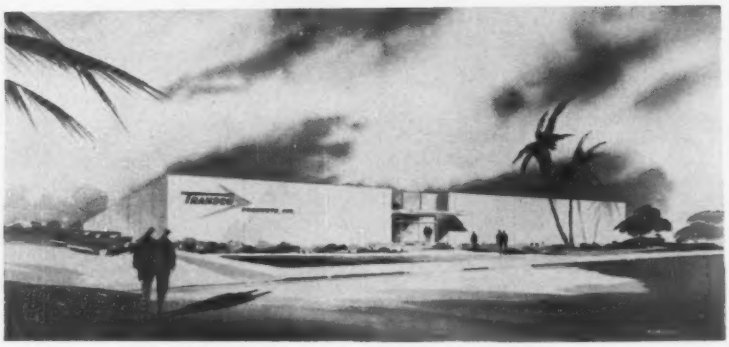
CIRCLE 105 ON READER SERVICE CARD



Transco Building Larger Facilities

TRANSCO PRODUCTS, INC., manufacturer of microwave systems and components, fractional h-p motors, and aircraft communication-navigation equipment, will move into new quarters at 4241 Glencoe Ave., Venice, Calif., next April.

The new facility, currently under construction on a 4½ acre site, will have 51,200 sq ft of working area, all on ground level—over twice as much space as the present Transco plant in West Los Angeles. Facilities are designed for the manufacture of high precision products.

The new plant will increase the engineering area three times, and provide an extensive microwave laboratory and new antenna pattern range. According to M. W. Sawyer, president, expansion (which follows by only one year complete modernization and enlargement of the present plant) was needed because of accelerated demand for company products and establishment of company in two new fields, motors and aircraft equipment.

McCord Assumes New Position

APPOINTMENT of A. Ray McCord as manager of the surveillance department in the Apparatus Division of Texas Instruments Inc., Dallas, Texas, has been announced. This department is primarily concerned with research, design and manufacturing of military surveillance and reconnaissance equipment, including infrared and radar systems and low altitude navigation systems.

McCord was formerly production manager in the division's manufacturing department. In his new position he replaces Lee Strom who has joined TI's Components Division as technical advisor in the integrated circuits group.

Diginamics Corp. Fills Two Posts

DIGINAMICS CORP. of Minneapolis has appointed two engineers to executive positions in charge of special project groups.

Keith J. Bulleyment was named principal systems engineer supervising the special digital systems group dealing with one-time digital systems. Edward G. Zoerb was appointed principal mechanical engineer in charge of the mechanical engineering group.

Both formerly were associated with the Aeronautical Division of Minneapolis-Honeywell Regulator Co.

Sanborn Establishes Transducer Division

SANBORN CO., Waltham, Mass., has established a transducer division with its own engineering staff and manufacturing facilities. The division will provide individual attention to the needs of military, industrial and medical equipment users.

Dytronics Hires Glogowski

STEFAN W. GLOGOWSKI has been appointed chief engineer for Dytronics Inc., Rochester, Mich.

Dytronics, a subsidiary of Taylor Fibre Co., Norristown, Pa., makes die stamped circuits for electrical and electronic applications.

Prior to joining Dytronics, Glogowski was a project engineer in the Metal Fabricating Division of DeVilbiss Co., Toledo, O.

Victor Fong Joins Clark Semiconductor

VICTOR FONG has been appointed manager of device fabrication for Clark Semiconductor Corp., Clark,

A POWER HOUSE

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Literally, BF Series Battery Holders are powerhouses . . . designed for use as highly stable, panel mounted cell sources of power. They will accommodate batteries and cells up to 1 3/8" diameter and lengths from 1 19/64" to 7 3/16", enabling use of different battery combinations to obtain wide selection of voltages. Batteries are exchanged simply by unscrewing holder cap. Designed for mounting up to a 1 3/8" diameter hole and 3/8" panel thickness.
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400 SERIES: • Accommodates batteries 1" to 1 3/8" diameter and lengths from 1 13/16" to 6 3/16".

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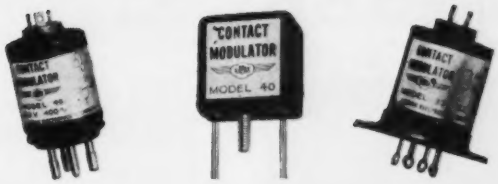

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Export Division: EMEC, Inc. Plainview, L. I., N. Y.

N.J. He will be in charge of the production of the company's high frequency power transistors.

Before joining Clark, Fong was an engineer for RCA Semiconductor division, and did development work for Bell Telephone Laboratories.

Cooper Accepts Cimron Post

EBERHARD COOPER, formerly an engineer at Cohu Electronics, Inc., has accepted the post of senior electronic engineer at Cimron Corp., San Diego, Calif.

At Cimron, Cooper will assume a major responsibility in the design of electronic instruments to augment the company's line of d-c and a-c digital voltmeters and volt-ratio meters.

PEOPLE IN BRIEF

Roy A. Olerud, ex-ITT and Allen B. DuMont Laboratories, is named general mgr. of Custom Components, Inc., and all its wholly-owned subsidiaries. Republic Aviation promotes **Everett S. Glines** to general mgr. of its missile systems div. **Norwood P. Cassidy,** former Assistant Comptroller of the Navy, elected president of Servonics, Inc. **Paul Garrison** leaves I.T.E. Circuit Breaker Co. to become general mgr. of Technical Appliance Corp. **John T. Whiteley,** previously with British Columbia Telephone Co., has joined the engineering staff at Lynch Communication Systems Inc. **Warner T. Smith** and **Robert M. Meadows** move up at Superior Cable Corp. to v-p in charge of engineering and treasurer, respectively. **N. R. Kornfield** advances at Philco Corp. to mgr. of the special projects dept. in the Computer Div. Dunn Engineering Corp., ups **Sydney Minault** to v-p, manufacturing. **Murray I. Disman,** of Eitel-McCullough, Inc., appointed mgr. of microwave tube development. **John M. Lambert,** ex-General Electric Co., named mgr. of advanced systems in the Systems Div. of Avien, Inc. **Samuel W. Daskam,** formerly with RCA, is now applications mgr. at Clark Semiconductor Corp.

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SEC high-precision capacitors utilize polystyrene, providing .01% tolerances, and mylar and teflon to meet .5% requirements. They show excellent stability characteristics over an extended temperature range, and tolerances are unaffected even at extreme high altitudes.

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Our engineering experience enables us to meet **your** size requirements, while holding to exact capacitance and tolerance specifications.

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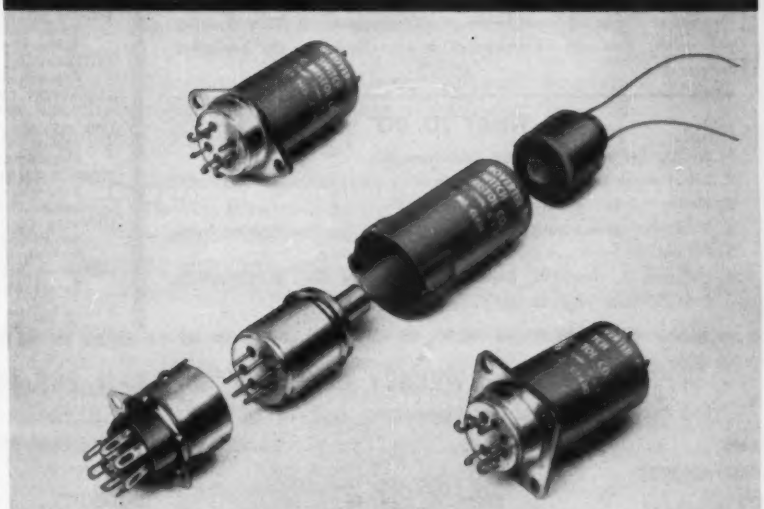
open the way for new advances in low-level instrumentation



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electronics

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GENERAL DYNAMICS/ELECTRONICS Military Products Div. San Diego, California	116*	5
GENERAL ELECTRIC CO. Missile & Space Vehicle Dept. Philadelphia, Pennsylvania	113*	6
HUGHES AIRCRAFT COMPANY Aerospace Engineering Div. Culver City, California	17	7
HUGHES AIRCRAFT COMPANY Space Systems Div. Culver City, California	17, 18*	8
INTERNATIONAL ELECTRIC CORP. Paramus, New Jersey	101	9
LABORATORY FOR ELECTRONICS Boston, Massachusetts	94	10
LINK DIVISION General Precision Inc. Binghamton, New York	92*	11
LITTON SYSTEMS INC Data Systems Div. Canoga Park, California	111*	12
LOCKHEED CALIFORNIA CO. Div. of Lockheed Aircraft Corp. Burbank, California	50*	13
MICROWAVE SERVICES INTERNATIONAL, INC. Denville, New Jersey	112	14

CONTINUED ON PAGE 112

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electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME .....

HOME ADDRESS .....

CITY .....ZONE.....STATE.....

HOME TELEPHONE .....

Education

PROFESSIONAL DEGREE(S) .....

MAJOR(S) .....

UNIVERSITY .....

DATE(S) .....

FIELDS OF EXPERIENCE (Please Check)

12151

☐ Aerospace	☐ Fire Control	☐ Radar
☐ Antennas	☐ Human Factors	☐ Radio—TV
☐ ASW	☐ Infrared	☐ Simulators
☐ Circuits	☐ Instrumentation	☐ Solid State
☐ Communications	☐ Medicine	☐ Telemetry
☐ Components	☐ Microwave	☐ Transformers
☐ Computers	☐ Navigation	☐ Other
☐ ECM	☐ Operations Research	☐ .....
☐ Electron Tubes	☐ Optics	☐ .....
☐ Engineering Writing	☐ Packaging	☐ .....

CATEGORY OF SPECIALIZATION

Please indicate number of months experience on proper lines.

	Technical Experience (Months)	Supervisory Experience (Months)
RESEARCH (pure, fundamental, basic)	.....	.....
RESEARCH (Applied)	.....	.....
SYSTEMS (New Concepts)	.....	.....
DEVELOPMENT (Model)	.....	.....
DESIGN (Product)	.....	.....
MANUFACTURING (Product)	.....	.....
FIELD (Service)	.....	.....
SALES (Proposals & Products)	.....	.....

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

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Technical Staff — communications and data systems

Systems test planning

Systems reliability analysis

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Field tracking station activation

Tracking and control systems design

Logistics and station support

And others

U.S. citizenship or current transferable Department of Defense clearance required.

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(Continued from page 111)

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electronics

WEEKLY QUALIFICATIONS FORM FOR POSITIONS AVAILABLE

(Continued from page 110)

COMPANY	SEE PAGE	KEY #
MITRE CORPORATION Bedford, Massachusetts	48	15
PAN AMERICAN WORLD AIRWAYS INC. Guided Missiles Range Div. Patrick AFB, Florida	34	16
PHILCO WESTERN DEVELOPMENT LABORATORIES Palo Alto, California	111	17
SCIENTISTS, ENGINEERS & EXECUTIVES INC. Washington, D. C.	116*	18
P-7843	116*	19

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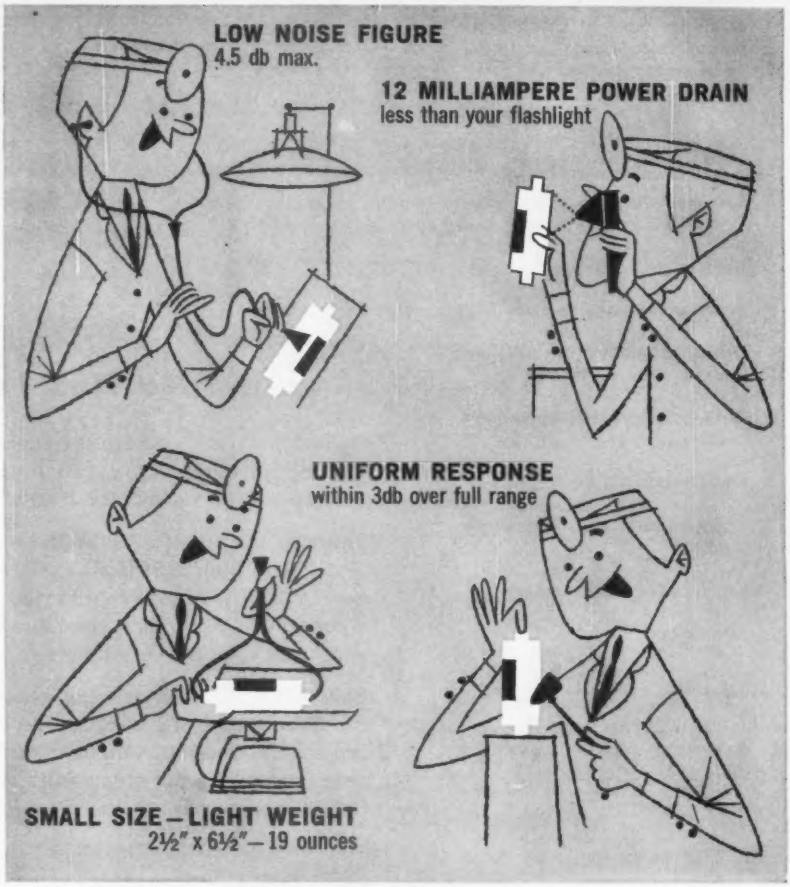

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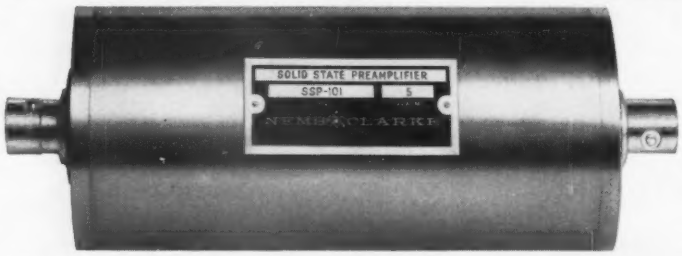

Here's your baby for outstanding performance and economy in the 225-260 megacycle telemetry range—the Nems Clarke SSP-101 completely solid state preamplifier. Featuring extremely low noise, flat response, and a hefty 25db minimum gain, it's at home in any environment . . . installed either in the antenna mount or the coax cable. Its own external 12 volt power supply is available for rack mounting. Baby sitting? Forget it! The SSP-101 operates for thousands of trouble free hours at unattended locations.

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INDEX TO ADVERTISERS

Audited Paid Circulation

- **AMP Incorporated** 54
- Ace Electronics Associates, Inc..... 96
- **Acme Electric Corp**..... 20
- Aerocom 51
- Aerospace Corporation..... 42
- Air Express 25
- **Airpax Electronics, Inc**..... 107
- **Alco Electronic Products Inc**..... 103
- American Machine & Foundry Co..... 24
- **Arnold Magnetics Corp**..... 24

- Baird-Atomic, Inc. 87
- Barnstead Still & Sterilizer Co..... 14
- Bausch & Lomb, Inc..... 88
- Behlman-Invar Electronics Corp..... 89
- **Bendix Corporation Red Bank Division**..... 81
- **Birtcher Corporation, The**..... 36
- Bristol Company, The..... 109
- Bruno-New York Industries Corp.... 46

- Cambridge Thermionic Corp..... 92
- Cominco Products Inc. 40
- **Cosmic Condenser Co.**..... 103
- Cunningham 40

- Data-Control Systems, Inc..... 105
- **Dorsett Electronics, Inc**..... 89
- **Durant Manufacturing Co**..... 36
- Dymec, A Division of Hewlett Packard Co. 29
- Dynacor, Inc., A Sub. of Sprague Electric Co. 113

- **Edgerton, Germeshausen & Grier, Inc.**. 36
- Electronic Engineering Co. of Calif.. 46
- Electronic Research Associates, Inc.. 100

- **FXR, A Div. of Amphenol-Borg Electronics Corp.** 3
- **Fenwal Electronics, Inc**..... 101

- **General Ceramics, Div. of Indiana General** 15
- **General Electric Co.**
  Chemical Materials Dept.....84, 85
  Silicone Prods. Dept..... 49
  Power Tube Dept. 44, 45
- Gertsch Products, Inc..... 93
- **Gudebrod Bros. Silk Co., Inc**..... 32

- **Hardwick-Hindle, Inc.** 99
- **Hayes, Inc. C.I.** 50
- **Hewlett-Packard Company** **Inside front cover**
- Hogan Faximile Corp..... 50
- Hughes Aircraft Co. 17

- IBM 22, 23
- Intellux Inc. 46
- International Electric Corp..... 101

- **Kintel, A division of Cohu Electronics Inc.** .....3rd cover
- Krohn-Hite Corp. 99

- Laboratory for Electronics Inc..... 94
- **Lafayette Radio**..... 109
- Lincoln Laboratory 103
- **Litton Industries, Electron Tube Division**..... 52

- Magnetic Metals Company..... 77
- Mallory and Co., Inc., P. R....8, 9, 82, 83
- Mesur-Matic Electronics Corp..... 102
- Minnesota Mining & Mfg. Co. Magnetic Products Div..... 47
- Mitre Corp., The..... 48
- **Mitsumi Electric Co., Ltd**..... 40
- **Mnemotron Corp.** 94

- Narda Microwave Corporation..... 13

- Ozalid, A Div. of General Aniline & Film Corp. 2

- Pamotor, Inc. 20
- Pan American World Airways Inc.... 34
- **Panoramic Electronics, Inc.** 93
- **Permag Corp.** 50
- Precision Instrument Co..... 95

- Radiation Inc. 33
- **Radio Corporation of America**..... 21
- **Raytheon Company**..... **4th cover** 5

- **Sanborn Company** 41
- Sangamo Electric Co. 7
- Scientific Development Corp..... 20

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Security Devices Laboratory 107
• **Sierra Electronic Corp** 10
• **Sorensen & Co** 18, 19
• **Southern Electronics Corp** 108
Sperry Electronic Tube Div. Sperry Rand Corp. 78, 79
Sprague Electric Co. 30, 31, 91
Stackpole Carbon Co 38, 39
Struthers-Dunn 104

TWA Air Freight 47
Telrex Laboratories 89
Teltronics, Inc 108
Texas Instruments Incorporated Components Division 75
Thermal American Fused Quartz Co., Inc. 6

United Shoe Machinery Corp. 101
Universal Cyclops Corp. 35

Veeder-Root, Inc. 53
• **Vitro Electronics** 112

Wallar Corp., The 85
Western Electric 16

■

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

EMPLOYMENT OPPORTUNITIES. 111, 112

INDEX TO CLASSIFIED ADVERTISERS

Esquire Personnel 112
Microwave Services International Inc... 112
Philco Western Development Labs..... 111

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JULY 20, 1961

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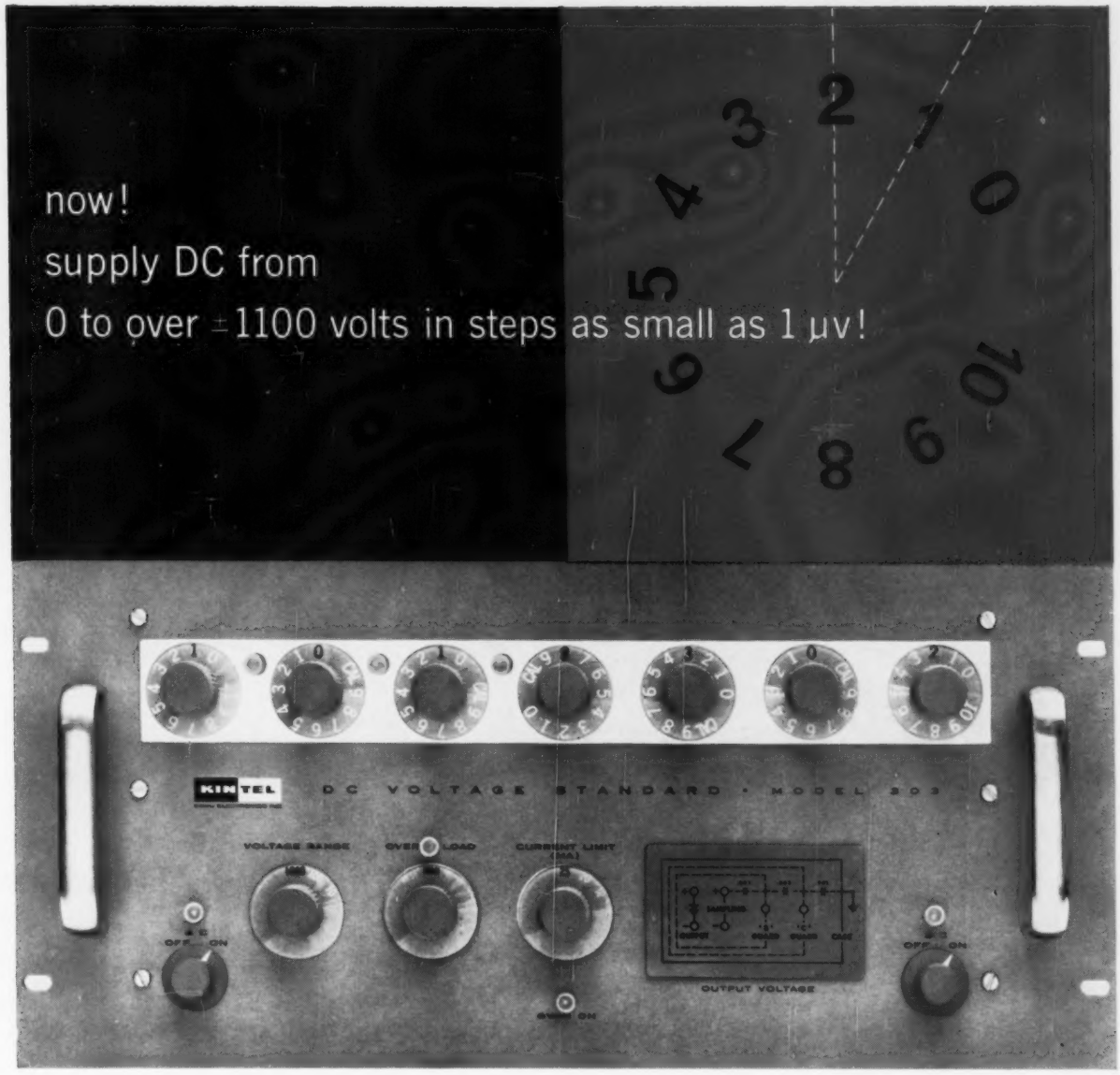

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Nuclear interactions in a bubble chamber, courtesy of Brookhaven National Laboratory

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